INSTRUMENTS and AUTOMATION

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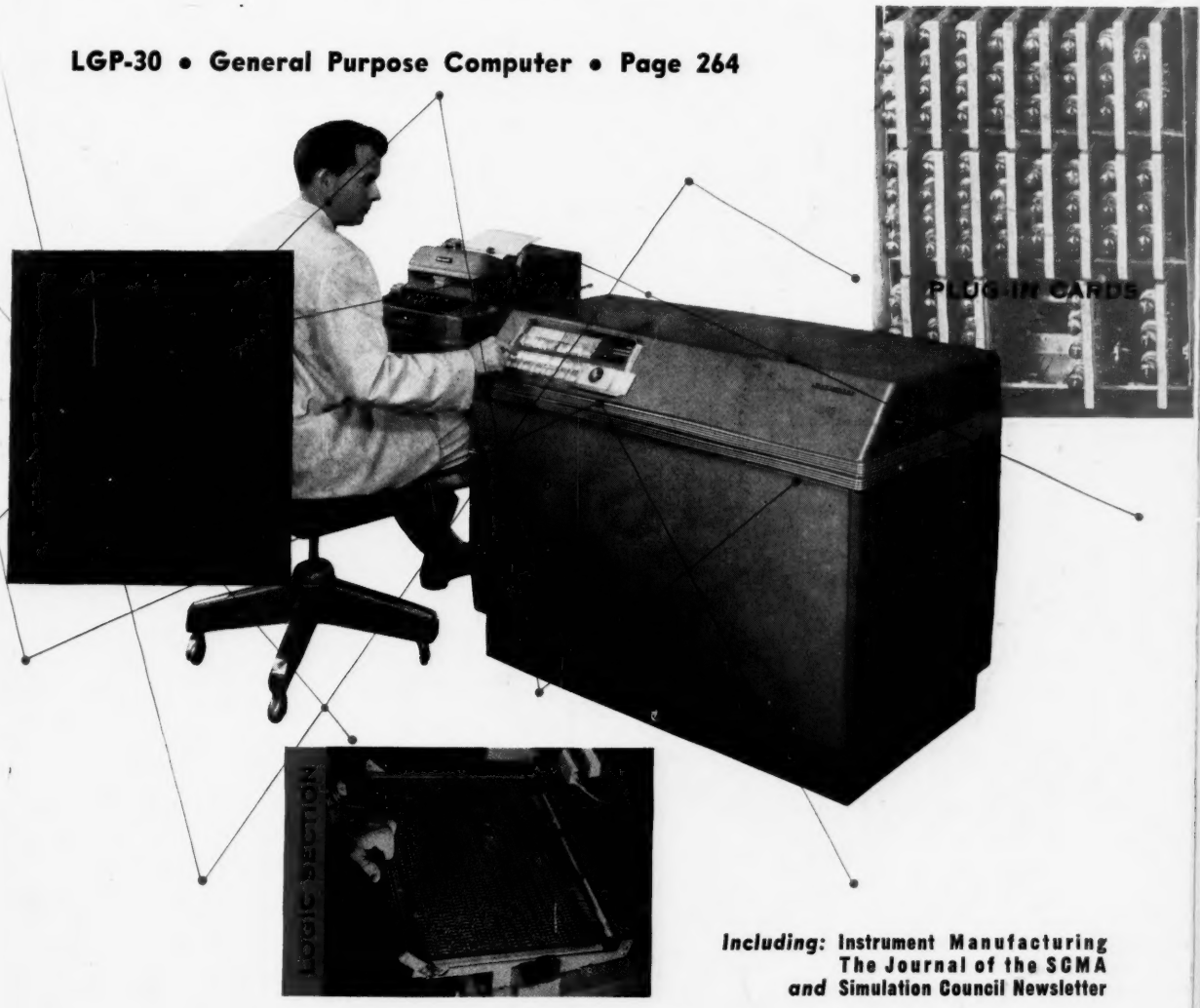
LGP-30 • General Purpose Computer • Page 264

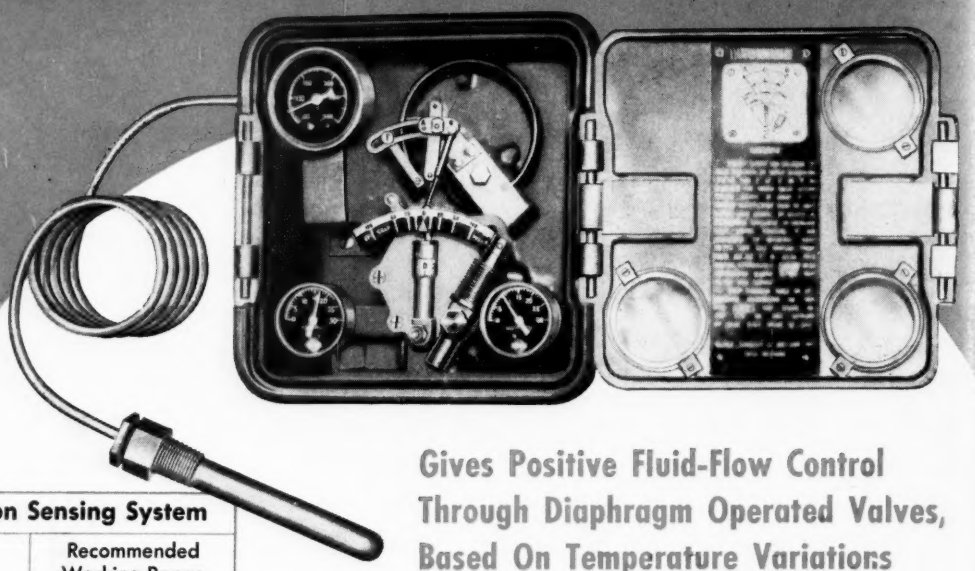


Including: Instrument Manufacturing
The Journal of the SCMA
and Simulation Council Newsletter

VOLUME 29 NO. 2 FEBRUARY 1956

Introducing...

The New BS&B Type 1460 Temperature Controller



Vapor-Tension Sensing System	
Bulb Range	Recommended Working Range
0-100° F.	20-90° F.
40-140° F.	60-130° F.
40-240° F.	90-220° F.
100-350° F.	175-335° F.

Gives Positive Fluid-Flow Control Through Diaphragm Operated Valves, Based On Temperature Variations

The new BS&B Type 1460 Temperature Controller or Pilot is equipped with an external vapor-tension thermal system to actuate the power unit in the pilot.

Except for this actuating mechanism and the temperature indicator which is an integral part of it, the 1460 Controller has all of the excellent features offered in the well-known BS&B Type 1440 Control Pilot—including the ¼" supply medium reducing regulator and two pressure gauges.

This unit is especially suited for translating temperature variations to direct flow-control of fuel, or of heating or cooling medium, through diaphragm operated valves.

FEATURES

- Vapor-Tension Sensing System
- Choice of Temperature Ranges
- Built-In Temperature Indicator
- Simple Adjustment Permits Either 100% Throttling Action—Or "On-Off" Snap Action Within A Wide Limiting Range.
- Parts Interchangeability With BS&B 1440 And 1450 Pilots Reduces Maintenance Cost And Parts Inventory.

Ask your BS&B Representative for more details—or write to...

BS&B — OVER 60 YEARS — EFFICIENCY RELIABILITY — ANOTHER EXAMPLE OF PRODUCT LEADERSHIP

BLACK, SIVALLS & BRYSON, INC.

Controls Division, Dept. 4-V2,

7500 East 12th Street Kansas City 26, Missouri

For more information circle 1 on inquiry card.

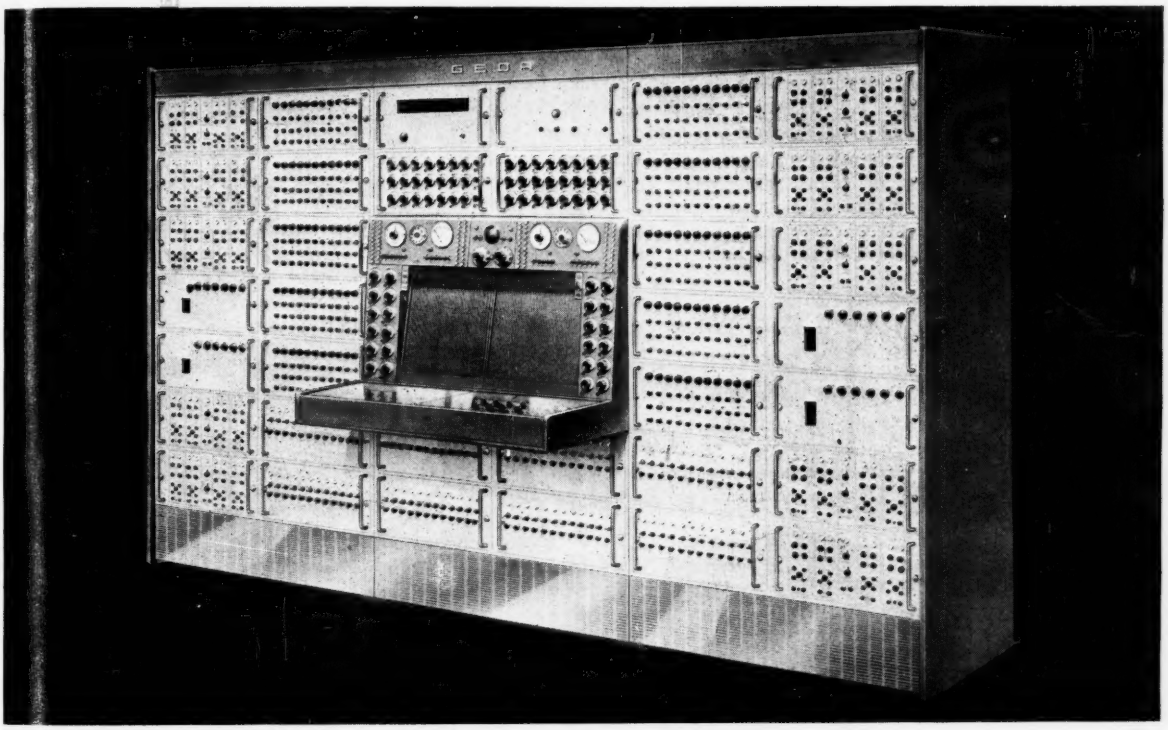
Now—

the newest, most accurate Analog Computer

Goodyear Aircraft Corporation proudly presents its A-14 Series, spectacular additions to the GEDA family of general purpose analog computers and computing accessories.

The new A-14 GEDA console offers:

- The most accurate, widest-band linear computing equipment.
- The most precise high speed electronic nonlinear equipment.
- The widest selection of accessory equipment.



GEDA
ANALOG COMPUTERS

The GEDA A-14 series is the most advanced, most flexible analog computer combination available. It allows you to purchase only what you need today, change or expand it as conditions require. You'll be surprised at the low cost of a GEDA A-14 series installation, custom-designed to your exact needs.

You really should know more about this truly modern approach to technological advancement. Write: Goodyear Aircraft Corporation, Department 931EN, Akron 15, Ohio.

The way to give your hunch a chance

GOODYEAR AIRCRAFT

GEDA—T. M. Goodyear Aircraft Corporation, Akron 15, Ohio

For more information circle **2** on inquiry card.

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for cabinets, instrument panels, weldments, enclosures, cubicles, housings, chassis, consoles—

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The measure of any company is its reputation—and for 85 years now, Falstrom has been the outstanding name in the sheet metal fabricating field. Under one roof, Falstrom maintains complete design and production facilities including the latest metal working equipment—all backed by men whose experience embraces every type of enclosure requirement. For all work in aluminum, steel and other alloys write for bulletin 142.

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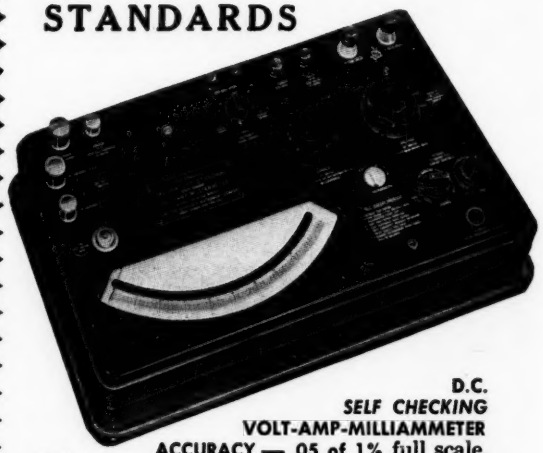
Sensitive Research

LABORATORY STANDARDS



D.C.
SELF CHECKING
VOLT-AMP-MILLIAMMETER
Model BS
ACCURACY — .05 of 1% full scale.
20 RANGES — .1 volts to 3,000 volts and 1 M.A. to 30 amps. full scale.
Internal Standard Cell—12" Hand Drawn Mirrored Vernier Scale.

Model THACH

A.C.-D.C.
SELF CHECKING
VOLT-AMP-MILLIAMMETER
ACCURACY—.2 of 1% DC and AC to 4,000 CPS.
19 RANGES — 1 volt to 1,000 volts and 10 M.A. to 5 amps. full scale.
Internal Standard Cell — 6" Hand Drawn Mirrored Scale.

LABORATORY STANDARDS listed below have an accuracy of .1 or 1% and 12" hand drawn mirrored vernier scales.

Model DYL — 18 Ranges AC Current and Voltage from 50-500 CPS.
Model L — DC and AC from 30 V. and 50 M.A.
Model B — DC from 30 Microamps and 50 M.V.
Model LW — DC and AC from 25 Watts at 20% PF.

Inquiries Invited — Write Dept. IA 5.

SENSITIVE RESEARCH INSTRUMENT CORPORATION
NEW ROCHELLE, N. Y.

Symbol of Quality . ELECTRICAL INSTRUMENTS OF PRECISION SINCE 1907

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Automation, Revolution and Insight 257

Feature Articles

LGP-30 General-Purpose Digital Computer 264
Stanley Frankel and James Cass

Basic Circuits Used in Digital Automation 271
Martin Klein, Frank K. Williams and Harry C. Morgan

Valve Piping Effects 280
G. F. Brockett and W. J. L. Kennedy

Valve Capacity and C_v 282
C. S. Beard

Instrumentation for a Continuous Strip Steel Annealing Line 285
A. B. Chamberlin, Jr.

Electronic Circuitry 288
Charles Kezer and Milton H. Aronson

The Steel Industry Has Plans for Multipoint Recorders 290
J. A. Milnes

Journal of the Southern California Meter Association

Trends in Process Automation 294
Glen G. Gallagher and Robert A. Robinson

The Simulation Council Newsletter 301

Other Regular Features

Letters to the Editor ... 199
Inquiries 202
Trends 211
Panhandle Pete 217
News 221
Stock Report 230
Biographies of Significance 247
Books 305
Events Calendar 308
New Instruments 310
Briefs 356
New Literature 368
Searchlite Section 384
Advertisers' Index 386
Inquiry Card 387

THE MAGAZINE OF INSTRUMENTATION AND AUTOMATIC CONTROL FOR 28 YEARS — SINCE JANUARY 1928

Instruments and Automation (including Instrument Manufacturing) published monthly by The Instruments Publishing Company, Inc. Office of publication, 1600 North Main Street, Pontiac, Illinois. Executive and Editorial Office, 845 Ridge Avenue, Pittsburgh 12, Pennsylvania. Entered as second class matter January 26, 1932, at the post office at Pittsburgh under the act of March 3, 1879. Transferred permit October 14, 1949 to the post office at Pontiac, Illinois, under the act of March 3, 1879. Copyright 1956.

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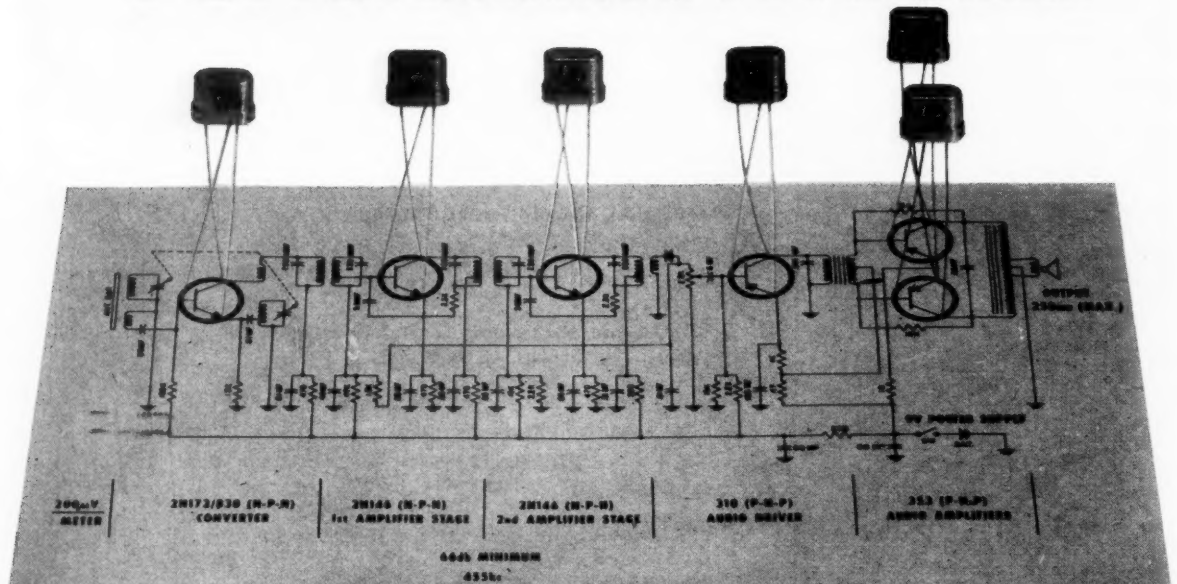
TI PROGRESS REPORT ON RADIO TRANSISTORIZATION

Performance . . . not promises!



Texas Instruments germanium transistors are used in 85% of the many brands of transistorized radios now being manufactured! Since TI transistors made possible the FIRST transistorized radios 15 months ago, improved mass production methods have rapidly increased performance and decreased prices.

In less than a year and a half, progress in TI transistors and radio circuits has been so swift that the following improvements are now production realities:

	1954	1955
Sensitivity	2000 μv/m	200 μv/m
Operating Voltage	22½V	6, 9, or 12V
IF Gain & Frequency	31db@ 262 kc	35db@ 455 kc
IF Output Capacity (C_{ob})	30-40 μμf	1 μμf
IF Neutralizing Capacity	Selected	Fixed
Audio Output Power	20mw	250mw
Typical IF Transistor Price (In complete OEM kit)	$2.50	$1.75

IN THE CIRCUIT ILLUSTRATED ABOVE:

Left to right: a 2N172/830 germanium N-P-N graded junction converter, two 2N146 germanium N-P-N graded junction IF amplifiers, a 310 germanium P-N-P fused junction driver, and two 353 germanium P-N-P fused junction outputs. This is a typical TI circuit designed for optimum performance.

Your *own* transistorized product development will also benefit from Texas Instruments progress which gives you proven products, immediate availability in production quantities, and economical prices. *First* with transistors in commercial radios, *first* with high gain, low voltage IF transistors, *first* with high temperature silicon transistors . . . Texas Instruments consistently leads the industry in development and manufacture.

LOOK TO TI FOR: GERMANIUM RADIO AND GENERAL PURPOSE TRANSISTORS • SWITCHING TRANSISTORS • SILICON SMALL SIGNAL AND POWER TRANSISTORS • SILICON JUNCTION DIODES

Texas Instruments has produced more radio transistors than any other manufacturer!

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6000 LEMMON AVENUE DALLAS 9, TEXAS

For more information circle 5 on inquiry card.

Letters to the editor

Editor, I&A:

We understand that a biographical sketch of D. J. Pompeo, Shell Development Company, with a short history of instruments developed by him has been scheduled for publication in *Instruments and Automation.*

Mr. Pompeo was recently recognized by his colleagues in the Northern California Section of the Instrument Society of America as an outstanding Instrumentation Engineer, and thereby becomes a candidate for the Outstanding Engineer Award to be presented on February 23, 1956, during the Bay Area Engineers' Week activities.

If your schedule permits, we should appreciate having the proposed article published in the February issue of *Instruments and Automation,* including, if possible, some mention of the recognition recently accorded Mr. Pompeo.

Claude B. Smith, Sec.
Instrument Society Of America
Northern California Section

See page 247

Editor, I&A:

In your *Instruments & Automation* magazine you have been running a series of articles by Klein, Williams and Morgan entitled "Digital Automation." We are interested in purchasing 15-25 copies of each of these articles.

Will the series be continued in 1956, and if so what would be the best procedure for procuring copies of them?

Donald I. Marr, Librarian
Airborne Computer Laboratory
International Business Machines Corp.

This important series will be continued in 1956—and will appear in book form at the conclusion. We will notify the hundreds of persons who have already expressed interest in the series of the availability of the book as soon as it is ready for distribution. Send us your name if you want notified personally.

Editor, I&A:

I was fascinated and impressed by your recent editorial in the August 1955 issue of *Instruments and Automation.* It is with a deep sense of appreciation that I wish to make my reactions known, even though I am not a specialist in the highly intricate and complex field which is now upon us. However, lacking know-how of all that complexity gives me a sense of greater admiration for the contributions mankind is realizing through men like you who delve into the mysteries of machinery and mechanisms to make them greater servants of the day, and lending themselves as tools by which we open new facets to the future.

I do have a request to make, in that I would cherish a copy of the editorial cited above. Futhermore, I intend to share it with my educator friends for the interesting concept in the way of a personal challenge to the reader.

O. E. Kangas
Office Methods Staff
Tennessee Valley Authority

We appreciate your kind letter—it is only when a writer hears from his readers that he knows whether he has made any impact or done anything constructive at all.

We surmise from your letter that you work on office methods, that you are not an engineer, and that you think our field of automation is mysterious and complicated.

One object of *Instruments & Automation* is to counteract the idea that automation machinery and mechanisms are mysterious or complex. For example, we are featuring a series on "Digital Automation," a series that portrays in beautifully simple yet thorough manner all the fundamentals of digital techniques which are basic to your field of office methods. You will find, if you read these articles, that an apparently complex and little-understood field of engineering becomes a thing of pure and simple beauty, with limitless applications opening to the man who understands the simple fundamentals.

Similarly, you will find in future issues of *Instruments & Automation* clear and thorough articles on the Clevite-Brush tapeDrum techniques for data control, on the Librascope and Bendix and IBM equipments for office automation, and others, all designed to show the applicability of modern automation equipments. Our primary object is to remove the "mystery" surrounding the mechanisms so that you will find that the mystery does not exist at all.

Editor, I&A:

As a new subscriber, I find *I&A* a very good magazine for anyone connected with instrumentation. I had mine sent to my home address, but I can see that it won't be long before it will be a must to enter another subscription to come to the office, so it won't be necessary to get the library copy each time I have a problem.

Your section on "Inquiries" is very good and here is one to add:

Harry G. Bangerter
Douglas Aircraft
Long Beach, Calif.

See Inquiry A-41 on page 202 for Harry's immediate problem.

Editor, I&A:

I am a student of Instrumentation at Ryerson Institute of Technology, in Toronto, and I am now entering my final year. The subject of my thesis is to be "Instrumentation as Applied to Boilers."

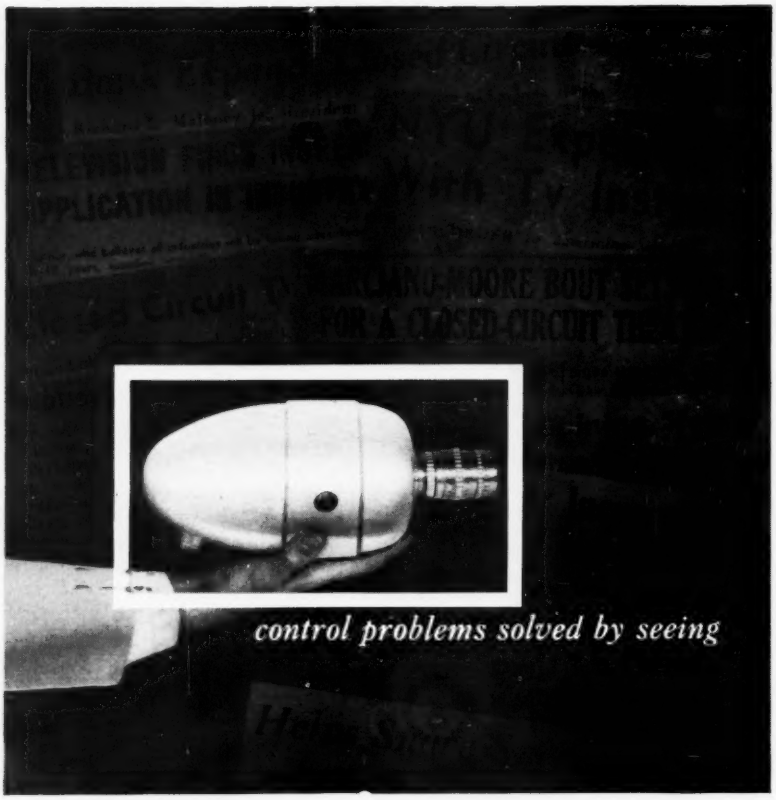
As a subscriber to your magazine *Instruments and Automation* I have gained a great deal of practical knowledge, but in your June, 1955 issue, I was exceptionally happy to discover an article entitled "Instrumentation of A Modern Steam Generating Facility" by J. P. Katzenmeyer of the U. S. Steel Corp. This article outlines some very interesting thesis material, which I should like to have in more detail.

William J. Duncan
Toronto 3, Ontario

The Katzenmeyer article (June, 1955) plus the article by Peth and Kotsch (December, 1955) plus the article by Hicks (January, 1956) add up to a powerful coverage of Automatic Steam Generation.

Editor, I&A:

You may be interested to know that Bristol did a whale of a good job in cleaning and repairing dam-



GPL *ii-TV*® is in the news

... *is it in your operation?*

GPL *ii-TV*, the *industrial* and *institutional* television system of General Precision Laboratory, is an important new control tool for industry—so new that in many fields its applications are just being explored. Already it is evident that it has a multitude of uses in supervision, and in monitoring both processes and machines. No process is too dangerous or too remote, too confined or too dispersed, too monotonous or too fast, for the keen eye of the *ii-TV* camera. And *ii-TV* is proving equally valuable in industrial training and in presenting information to management, in large or small groups.

Behind *ii-TV* are the skill and experience which have made GPL a leading manufacturer of broadcast and military TV equipment. The camera operates unattended, needs minimum light. The entire system is of highest quality, is portable and compact, easy to maintain.

We suggest that you let us help you explore how this new control tool can be used to advantage in your own operations.

JUST A FEW OF ITS MANY APPLICATIONS:

for Surveillance— Identity Checks— Process Control— Sales Meetings

General Precision Laboratory Incorporated
Pleasantville, New York
A SUBSIDIARY OF GENERAL PRECISION EQUIPMENT CORPORATION

For more information circle **6** on inquiry card,

ANY TASK

that can be better accomplished by instant transmission of visual information

IS A TASK FOR

GPL *ii-TV*®

the closed-circuit television system that makes visual communication as easy as the telephone makes verbal communication.

ii-TV Camera, control equipment and monitor, PD 150

Highly sensitive camera needs minimum of light; weighs only 5 lbs. . . . fits into tight places; operates unattended. Available with weather-, heat-, shock-, and explosion-proof housings. Only camera is needed at pick-up location.

Controls and monitor can be located far away. Anyone can operate the system.

GPL Television Projector, PB 611, makes it possible for large groups to watch together. Provides bright, steady pictures. Control console is wheel-mounted for mobility. Does not require skilled operator. High quality sound circuits feed standard sound system.

LETTERS—CONTINUED

aged Bristol Instruments right after the recent flood. We had servicemen on the job the next day, and between the instruments that were repaired and cleaned up at our customer's plants and those that were taken to our plants, we were able to put the majority of the instruments back into operation within a few days, and in all cases were able to meet the deadline set up by our customers.

Bristol is set up to give field service any place in this country on short notice. Our service department is very proud of its record. They have always been able to come through for Bristol customers even during disasters, working under very trying conditions.

G. P. Lonergan, Mgr.
Sales Promotion Dept.
The Bristol Company

Little known or appreciated is the dramatic story of how the field agencies and representatives of American instrument manufacturers rushed into the plants and factories that had been "understream" and, within a period of hours, had them back "on stream."

Editor, I&A:

Your editorial on "Automation and Economics" is excellent. First, it breaks down automation into the four parts you have given, thus eliminating some of the confusion in the jumping from one field to another without any regard for the jump. Second, of course, it gets into economic facts.

It was a real pleasure to read your remarks and to find somebody being a little blunt on the subject.

Nelson Gildersleeve
General Electric Company

We like direct, blunt facts too. It is a pleasure to learn that such blunt facts can compete with the flood of nonsense spewing everywhere on the subject of automation.

Editor, I&A:

The editing of our manuscript has been excellent. We are very fortunate to have selected you and your magazine as our place of publication.

M. H. LaJoy,
Associate Professor
University of Minnesota

Good manuscript is a pleasure to edit! The book "Process Control Analysis" by Millard H. LaJoy and E. Allen Baillif is now on the press, and will be available before the month (February) is over. See announcement on page 217.

KEARFOTT FILLS THE BILL
AIRCRAFT AND MISSILE CONTROL SYSTEMS
BILL OF MATERIAL
ITEM
PURCHASE FROM
✓ GYROS — KEARFOTT
✓ SYNCHROS — KEARFOTT
✓ SERVO MOTORS — KEARFOTT
✓ PRECISION TACHOMETERS — KEARFOTT
✓ MECHANICAL COMPUTER COMPONENTS — KEARFOTT
✓ INDICATORS — KEARFOTT
✓ PRECISE GEAR TRAINS — KEARFOTT
✓ AMPLIFIERS — KEARFOTT
REMARKS:
Specify KEARFOTT for all Servo System Components and Gyros!

Long years of experience in the development and production of precision servo system components enables Kearfott to offer you the *right* component for every function in your servo system. Kearfott components are available in a wide range of miniature and sub-miniature sizes, light weights and high accuracies. Many components are suitable for high temperature applications. Engineering data sheets fully describe the many Kearfott Components in production.

Send for Bulletin describing components of interest to you.

ENGINEERS
Many opportunities in the field of precision components and systems are open. Write for details today.

Kearfott

A SUBSIDIARY OF GENERAL PRECISION EQUIPMENT CORPORATION

KEARFOTT COMPANY, INC., LITTLE FALLS, N. J.

Sales and Engineering Offices: 1378 Main Avenue, Clifton, N. J.
Midwest Office: 188 W. Randolph Street, Chicago, Ill. South Central Office, 6115 Denton Drive, Dallas, Texas
West Coast Office: 253 N. Vinedo Avenue, Pasadena, Calif.

For more information circle **7** on inquiry card.

MODEL MH15A For mounting on drums having as few as 30 channels or as many as several hundred. Simple Design—Flexible Operation—Low Noise—High Voltage Insulation. Moisture Proof unit completely encapsulated.

CHARACTERISTICS

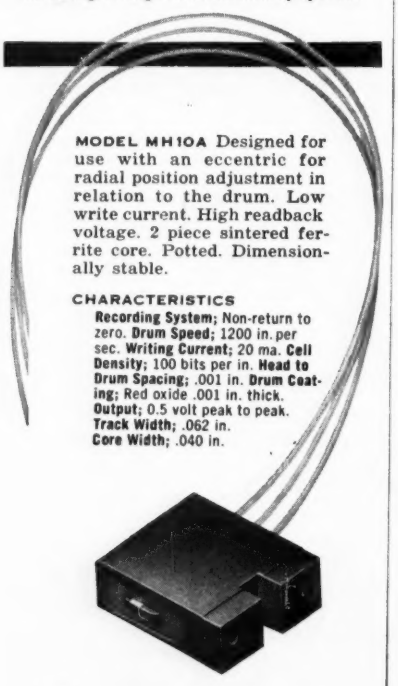
Recording System; Non-return to zero. **Drum Speed;** 2300 in. per sec. **Writing Current;** 70 ma. **Cell Density;** 100 bits per in. **Head to Drum Spacing;** .001 inch. **Drum Coating:** Red oxide, .001 in. thick. **Output;** 1 volt peak to peak. **Track Width;** .125 in. **Core Width;** .090 in.

The performance characteristics of Model MH15A can be incorporated in the MH10A case if desired.

LIBRASCOPE

READ-RECORD HEADS

Specifically Designed for Reading or Recording on Magnetic Drum Memory Systems



MODEL MH10A Designed for use with an eccentric for radial position adjustment in relation to the drum. Low write current. High readback voltage. 2 piece sintered ferrite core. Potted. Dimensionally stable.

CHARACTERISTICS

Recording System; Non-return to zero. **Drum Speed;** 1200 in. per sec. **Writing Current;** 20 ma. **Cell Density;** 100 bits per in. **Head to Drum Spacing;** .001 in. **Drum Coating;** Red oxide .001 in. thick. **Output;** 0.5 volt peak to peak. **Track Width;** .062 in. **Core Width;** .040 in.

Other models available... write for brochure.

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A SUBSIDIARY OF GENERAL PRECISION EQUIPMENT CORPORATION

808 WESTERN AVENUE • GLENDALE, CALIFORNIA

For more information circle 8 on inquiry card.

INSTRUMENTS and AUTOMATION Inquiries

The inquiries below were received from subscribers to **Instruments and Automation.** In most instances an answer has been sent, but we shall be glad to forward the name and address of the inquirer if you have any further suggestions.

Rubber Hardness Calibrator

Signal Corps Engineering Lab seeks manufacturer of "calibrating device for Shore A and D rubber hardness durometers." A-31

Magnetic Clutch Oil

Electrical Engineer seeks supplier of special oil used in magnetic clutches . . . particularly that which has tiny particles of iron in suspension and low viscosity until subjected to magnetic field. A-32

Momentary Contact Switch

Chemical corporation seeks source of momentary contact switch with mechanical time-delay device to control repositioning of switch . . . to be used for 110 v a-c. Time delay required is in order of 5 min. A-33

Computer Information

Purchasing consultant seeks literature on problem of application of computers to field of automatic dispatching in electric power plants. A-34

Rectifier Tester

Coal company seeks manufacturers of testing equipment for rectifier units. A-35

Chromel-Constantan TC

Test engineer seeks information on chromel-constantan thermocouple wire, such as ruggedness, service life, and thermal EMF output. A-36

Small Wattmeter

Motor manufacturer seeks small wattmeter for measurement of only 25 watts, in which one of the two inputs is electronic, thereby presenting a negligible load. A-37

Electronic Weighing

Foreign reader seeks information on electronic weighing equipment. A-38

Negative Temperature Coefficient Wires

Foreign reader seeks manufacturers of resistance wires whose resistivity decreases with increase in temperature. A-39

Electronic Servomechanisms

Italian reader seeks technical publications that deal exclusively with electronic servomechanisms and radar. A-40

Current-Measuring Board

Engineering Test Group at large aircraft manufacturing plant must often measure current, dc and ac (60 and 400 cps), from 0 to 10 amps, at many points. Instead of using many ammeters, engineer wants a plug board with plugs "mounted on 1" centers . . . for use in circuits to 200 v ac or in current transformer secondaries." Design must be "make before break" and capable of 10-amp continuous service. A-41

33-cps Shake Table

Reader needs vibratory apparatus with following specs: weight to be moved—2½ lbs; cycles per minute—2000 or over; movement distance—2½ inches; movement—straight line; use—in production. A-42

Quartz Crystal Manufacture

Reader seeks manufacturers of equipment for production of quartz crystals, including cutting and polishing units and optical and electrical testing units. A-43

Electronic Sub-Contract Work

Small manufacturer seeks electronic assemby or other electronic subcontract work. A-44

Paper-cup Tester

Paper cup manufacturer seeks testing machine for measuring resistance of paper to edgewise compression; particularly a ring crush tester. A-45

Compression Tester

Foreign manufacturer seeks source of "compression deflector tester for foam rubber, desired range of compression force 0 to 100 kg, for manual operation (handwheel & screw). Tester for mechanical stability of latex (ASTM-D 1076-54 T), desired speed of tester's motor about 14000 rpm, test cell should be glass and have dimensions: I.D. 2.28" ±0.04", height about 5" and wall thickness 0.09"." A-46

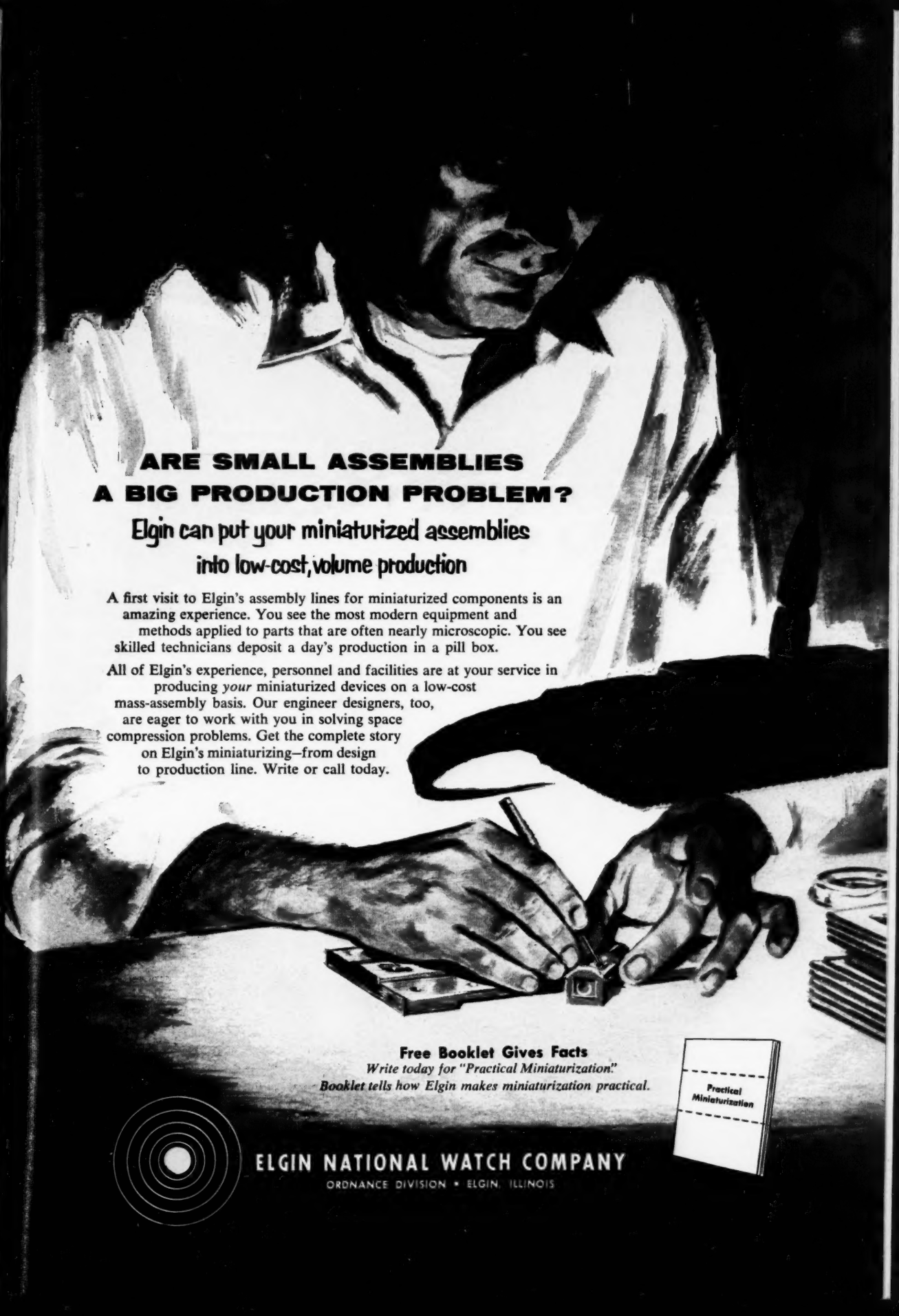
Ballistocardiographs

M. D. seeks instrument to measure ballistic recoil of the human body as the result of the contraction of the heart. A-47

Internal Caliper

Foreign firm seeks "instrument for measuring the internal diameter of . . . tubing in a cracking and refining process . . . a type of internal caliper which can be read directly from an electronic instrument." A-48

For more information circle 9 on inquiry card. →

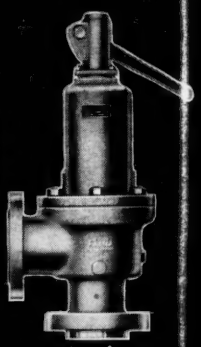

ARE SMALL ASSEMBLIES
A BIG PRODUCTION PROBLEM?
Elgin can put your miniaturized assemblies into low-cost, volume production
A first visit to Elgin's assembly lines for miniaturized components is an amazing experience. You see the most modern equipment and methods applied to parts that are often nearly microscopic. You see skilled technicians deposit a day's production in a pill box.
All of Elgin's experience, personnel and facilities are at your service in producing *your* miniaturized devices on a low-cost mass-assembly basis. Our engineer designers, too, are eager to work with you in solving space compression problems. Get the complete story on Elgin's miniaturizing—from design to production line. Write or call today.
Free Booklet Gives Facts
Write today for "Practical Miniaturization."
Booklet tells how Elgin makes miniaturization practical.
Practical Miniaturization
ELGIN NATIONAL WATCH COMPANY
ORDNANCE DIVISION • ELGIN, ILLINOIS

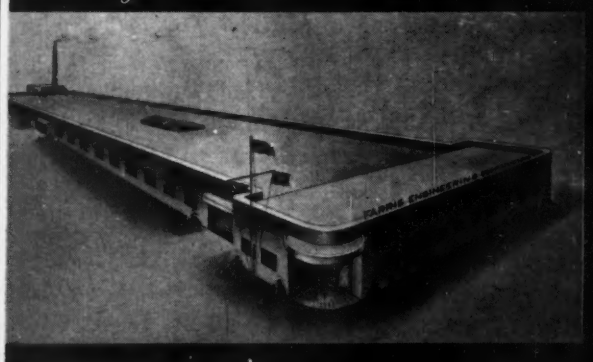
1943

"Progress"

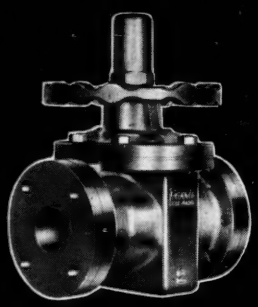
1944

Safety-Relief Valves
Balanseal Bellows Valves
Farris Engineering Corp.

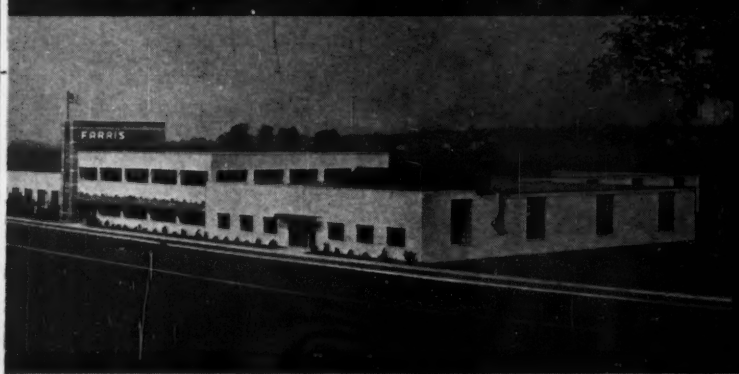




1945

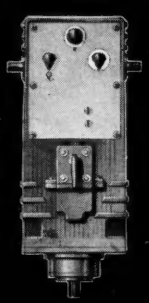


Pinch Type Flexible
Diaphragm Disc and
SuperSeal Valves
Farris Flexible Valve Corp.

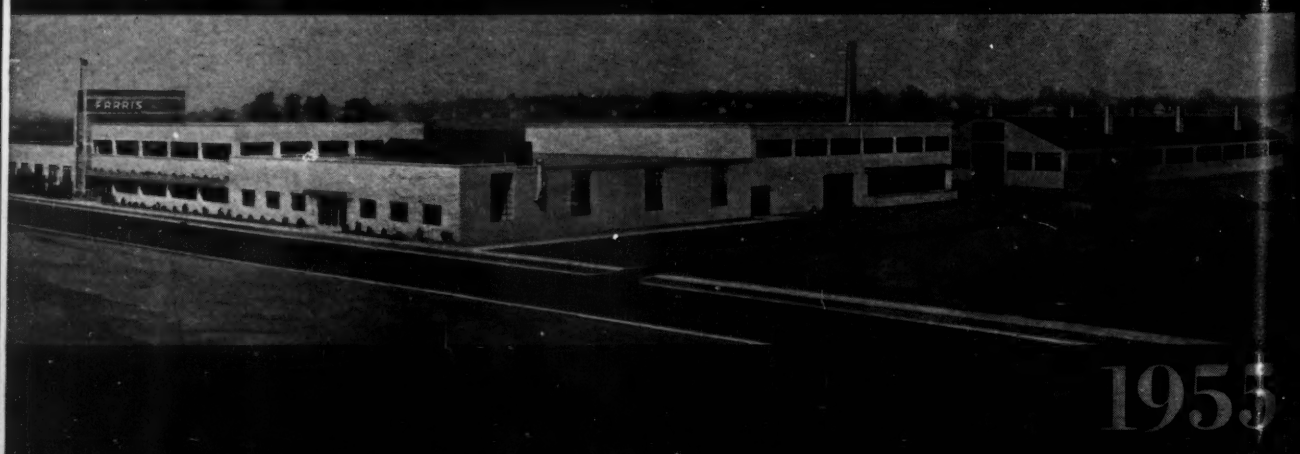


1951

Mechanical and
Hydraulic Governors
Farris Pickering
Governor Co., Inc.



U. S. Patents and Patents Pending



1955

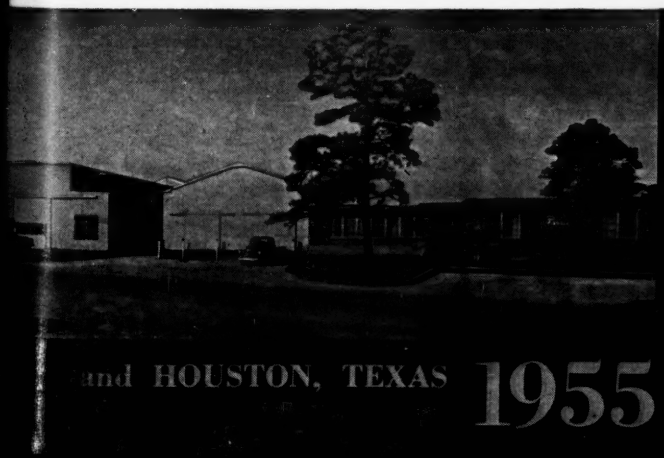
... through honest purpose"

The larger and more experienced a manufacturer becomes, the more he appreciates that PROGRESS is not restricted to simply producing fine products at fair prices. Rather, it is the sum total of all the services he renders to his customers day by day and year by year. It is unceasing vigilance to assure customer satisfaction . . . it is constant concern for improvement—for *better* products at even *better* prices . . . it is strict adherence to a commercial code of honor, like Farris' policy of "Progress—Through Honest Purpose".

Evidence of this policy's success is seen in the rapid and constant growth of the Farris organization. And even as you read this, more facilities are being added . . . designed to provide even greater service for users of Farris Safety and Relief Valves (which have set the pace in design and performance and have been duplicated by other manufacturers), Farris "SuperSeal" Flex Valves and Farris Pickering Governors.

Behind our continuing growth and the world-wide recognition of Farris as a pacesetter in its field, is the fundamental belief that "honesty of purpose" when dealing with people is always to be trusted. Upon this belief we have grown . . . and, because they believe in the same things, our customers and friends have supported us. Here, beyond doubt, is proof that the right way to grow is THROUGH HONEST PURPOSE.

For more information circle **10** on inquiry card.



and HOUSTON, TEXAS 1955

PROGRESS THROUGH Farris HONEST PURPOSE

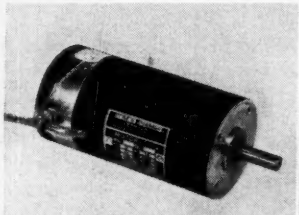
AFFILIATED COMPANIES

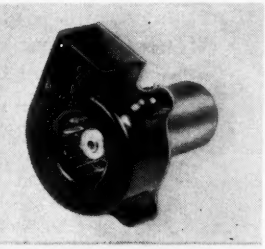
400 COMMERCIAL AVE., PALISADES PARK, N. J.

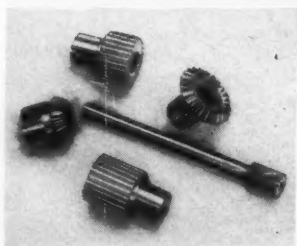
- Farris Engineering Corp.
- Farris Flexible Valve Corp.
- Farris Pickering Governor Co., Inc.
- Farris Hydrotorque Corp.
- Farris Hydroseal Corp.

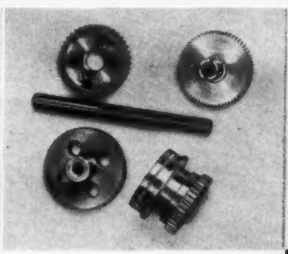
how to reduce costs with WESTERN GEAR rotary electrical equipment

We have more than 50 basic prototype motors, fans, blowers, converters, alternators and generators. Motor designs range from 1/500th to 4 HP, 50 to 1,000 cycles in frequency, any desired voltage. Extensive line enables economic modification to your requirements or special design. Complete engineering service gladly offered for help on any rotary electrical equipment problem. Write for new catalog No. 254-A.









Precision fine pitch gears, constructed to the highest specifications for electronics use, available from 200 to 6 diametral pitch and from .125" to 10" diameter. Complete engineering and manufacturing facilities for the application of high precision gearing and gear drives in electronics equipment. Ask for help on your problem. No obligation!

"The difference is reliability" • Since 1888

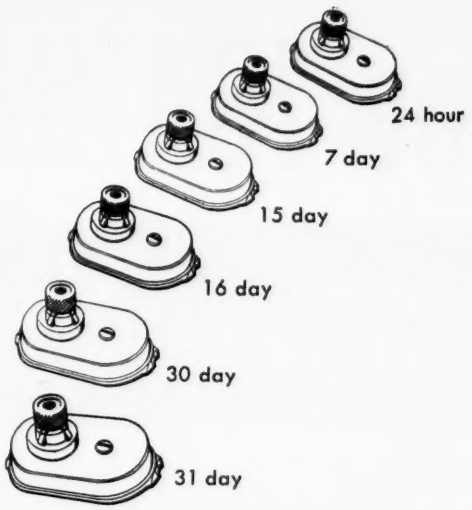
5506

Detail your requirement on any electronic problem. Utilize Western Gear's production facilities to cut your product costs. Our engineers will give their recommendations promptly. Address Western Gear Corporation, Electro Products Division, 132 W. Colorado St., Pasadena 1, Calif.

WESTERN GEAR Corporation
ENGINEERS AND MANUFACTURERS

PLANTS AT LYNWOOD, PASADENA, BELMONT, SAN FRANCISCO (CALIF.), SEATTLE AND HOUSTON — REPRESENTATIVES IN ALL PRINCIPAL CITIES

For more information circle **11** on inquiry card.



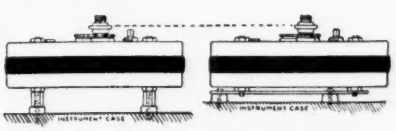
New ROCKWELL
31 DAY CHART DRIVE

For Complete Records Around The Clock

The turret on top does the trick

Stops Estimating Even though your meter man forgets to wind it, this new Rockwell 31 day drive will still provide a complete rotation for the chart period.

Saves Money The six different rotation rates (as illustrated) assure complete flexibility in your measurement program. You'll save through making less trips to the meter; having fewer charts to read.

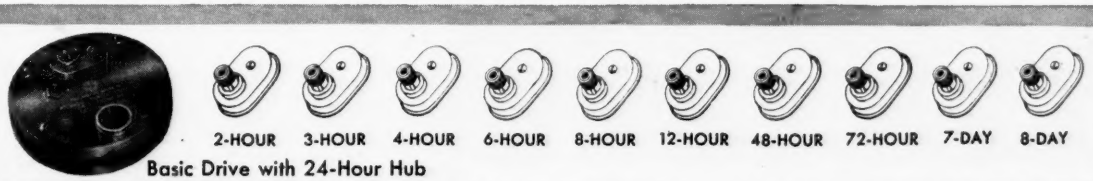


Fits Practically All Instruments The case dimensions are the same as the Rockwell Standard Chart Drive. Simple adaptors, as shown above, permit correctly locating it both as to position and height in practically any instrument.

ROCKWELL MANUFACTURING COMPANY
Instrument Division • Box 2396, Tulsa, Okla.

Atlanta Boston Charlotte Chicago Dallas Denver Houston Los Angeles
Midland, Tex. New Orleans New York N. Kansas City Philadelphia Pittsburgh
San Francisco Seattle Shreveport Tulsa

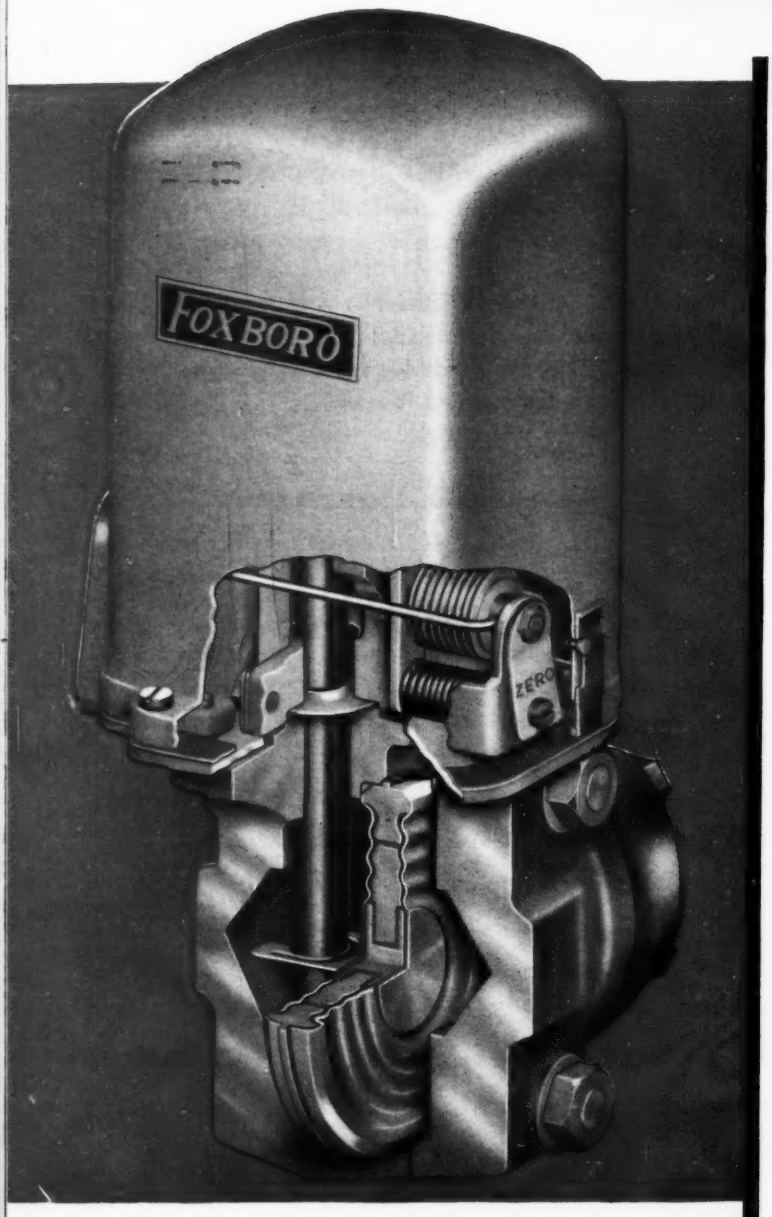
ALSO STANDARD ROCKWELL CHART DRIVES, 24 Hour Hub, 11 Rotations



Basic Drive with 24-Hour Hub

For more information circle 12 on inquiry card.

ONLY the Type 13A d/p has these 6 advanced-



- **Positive Overrange Protection** up to full 1500 lb. rating
- **Fully Adjustable Ranges . . .** 0-20" to 0-80" and 0-50" to 0-250" H_2O differential
- **Automatic Internal Damping** . . . fast, *stable* measurement
- **Simplicity** . . . easiest, lowest cost installation, least maintenance
- **Convenient Zero Adjustment** . . . external — no need to remove weatherproof cover
- **Highest Sustained Accuracy** . . . even under extreme operating and ambient conditions

With these basic features, plus many other technical refinements throughout, the new Type 13A d/p Cell* Transmitter surpasses all previous records in performance . . . economy . . . convenience. For the complete story and a demonstration, call your nearest Foxboro representative. Write for new Bulletin 13-11. **The Foxboro Company, 462 Neponset Ave., Foxboro, Mass., U.S.A.** Factories in the United States, Canada and England.

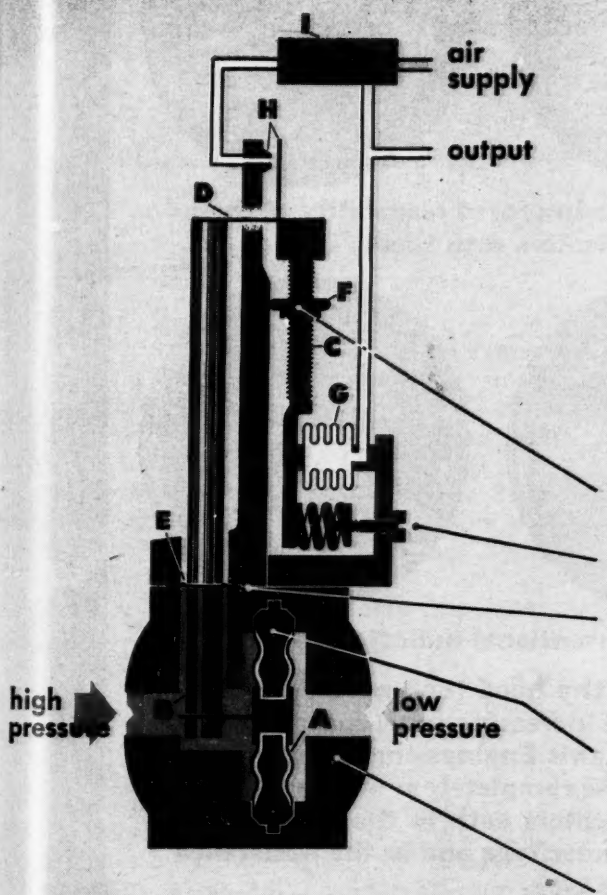
*Reg. U. S. Pat. Off.

More Foxboro flow transmitters are in use by the process industries than all other makes combined!

For more information circle **13** on inquiry card.

Cell Flow Transmitter

design features...



How It Works...

An increase in differential pressure across Twin-Diaphragm Capsule (A) exerts force to right on force bar (B). Elgiloy® diaphragm seal (E) acts as fulcrum. Force to left at top of bar (B) causes flapper to approach nozzle at (H). Resulting increase in nozzle pressure is amplified by relay (I). This pressure is sent to feedback bellows (G) which develops force to counterbalance the differential pressure on capsule (A). The 3-15 psi output signal from relay (I), always precisely proportional to differential pressure, is transmitted to remote recording or controlling instrument.

Range Wheel is continuously and easily adjustable for entire range whether 0-20" to 0-80" or 0-50" to 0-250" H_2O.

Easy-access screw adjustment permits field "zeroing" without removing weatherproof cover.

Elgiloy® stainless alloy diaphragm seal assures a corrosion-resistant, frictionless, positive pivot point. Instrument is constructed in 3 basic units — body, transmitter, and air relay block — eliminating all possibility of errors produced by piping stresses.

Silicone-filled Twin-Diaphragm Capsule filters out flow disturbances ("noise") at measurement source . . . without loss of speed of response. Precisely matched surfaces of diaphragms and capsule core provide "stops" which give positive overrange protection in both directions.

Rugged forged body, optionally Type 316 S.S. or carbon steel, gives greatest strength with least weight . . . ultra-compact design permits low cost mounting from flange taps.

FOXBORO
Reg. U.S. Pat. Off.

First in Flow Instrumentation

For more information circle **13** on inquiry card.

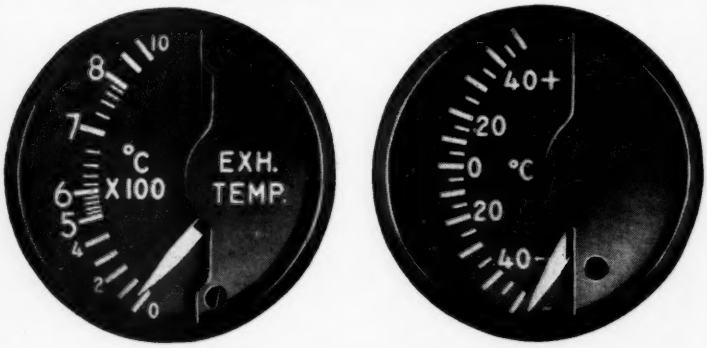
for improved readability, specify
the new **LEWIS**

LONG SCALE

aircraft temperature indicators

- Standard AND10412 cases
- Scale arc approximately 250°
- No auxiliary components
- No vacuum tubes
- Operate the same as conventional thermocouple type or resistance type temperature indicators
- Interchangeable with conventional temperature indicators, use standard resistance bulbs or thermocouples and leads
- Made to Military Standard Specifications
- Tested and Approved

COMPARE the improved readability of these long scale indicators with these . . .



Conventional indicators

Recognizing the need for improved readability without increasing panel space requirements, The Lewis Engineering Company has developed these completely new Aircraft Temperature Indicators both in the Thermocouple Thermometer type and in the Resistance Thermometer type.

the LEWIS ENGINEERING COMPANY
naugatuck, connecticut

For more information circle 14 on inquiry card.

INSTRUMENTS and AUTOMATION Trends

First hydroelectric plant in USA was built in 1882 at Appleton, Wisc; generated 12½ kw. Today, water power develops more than 50 million hp (equivalent to more than 37 million kw) in USA and Canada.

In 1900, electric utility generating capacity in USA was about 1 million kw; in 1925 it was 21.5 million kw; in 1954 it exceeded 100 million kw. Present capacity is comprised of about 75% fuel-burning and 25% hydroelectric plants. Fuel plants are about 96% steam plants, 3% internal-combustion plants, 1% gas turbine. Total capacity is expected to exceed 200 million kw by 1965.

Hours flown in business transportation have increased from 1 million in 1946 to 3.1 million in 1953 to estimated 3.9 million in 1954. Aircraft instrumentation is expanding at even greater rate.

Cumulative sales of receiving tubes for first three quarters of 1955 were reported by RETMA to be 347.7 million tubes with manufacturers' value of $257.5 million. This compares with 266 million tubes worth $192 million in the same 1954 period.

Serious problem in civil aviation: three nav-aids (VOR/DME, TACAN and DECCA) are competing for common international acceptance. USA airlines have "standardized" on 1000 Mc VHF omnirange (VOR) plus DME for distance data. New USA TACAN system (also 1000 Mc) is beacon-type tactical aircraft navigations system, but promises to replace VOR/DME. However, hyperbolic (master-slave transmitter type) DECCA system practically covers Britain, and other DECCA chains are in France, Germany and Denmark with others planned for Sweden, Italy and Spain. International Civil Aviation Organization (ICAO) has problem: It has specified VOR/DME as the international short-range nav-aid, but only USA implemented policy, and now both TACAN and DECCA are in picture.

Punched tape field is developing rapidly. Teletype is developing 180 character/second punch; Ferranti is developing 2000 character/second reader.

Two years have elapsed since FCC okayed color TV—and only 30,000 color TV receivers have been sold. Reason: price. Although P. G. Galvin, president of Motorola, predicts sales of 30 million color sets by 1965, big push is not expected until 1957-58. Servicemen need about $300-$900 worth of new instruments to service color TV receivers.

Export markets are expanding. Exports of electrical instruments in 1940 were less than $1 million; in 1953 they were $20 million. Control valve exports were $2 million in 1950; $10 million in 1953.

Tappan Stove Company has marketed first electronic kitchen range; 2400 Mc cooking unit was developed with Raytheon Mfg. Co.

FISHER®
DIAPHRAGM
FISHER
● Fisher Diaphragm Motor Valves are furnished in a wide variety of pressure ratings and materials. Topworks may be either direct acting (Series 657) or reverse acting (Series 667). Handjacks are available for either diaphragm casing mounting or yoke mounting. There are six diaphragm and yoke size combinations.

For more information circle **15** on inquiry card.

Improved

MOTOR VALVES

Improved PERFORMANCE FEATURES

- Bolted-clamp type stem connection allows stem adjustment of 50% of total travel. Can be disconnected in the field without stem damage. Will not shake loose from vibration or rotational inner valve forces.

- Rugged body to yoke connection with hammer lug nut. Topwork can be removed without disturbing stuffing box.

- Specially designed Buna N molded diaphragms with Nylon insert retain superior flexibility at low ambient operating temperatures. Provides linearity between operating pressure signal and travel, and gives maximum effective area.

- Bolted gland stuffing box with Teflon packing.

- Stainless steel clear view travel indicator.

- Spring ranges: 3 to 15 psi; 6 to 30 psi.

FISHER GOVERNOR COMPANY • Marshalltown, Iowa

WORLD LEADER IN RESEARCH FOR BETTER PRESSURE AND LIQUID LEVEL CONTROL

FISHER

Since 1880

GET THE FACTS YOU NEED AT ONCE

with Brush Recording Systems

This advanced instrumentation gives you immediate answers in writing. No plotting or charting of data. Direct written charts made while tests are underway save you hours of engineering time.

Here are a few of the ways design and development groups are now using Brush Recording Systems:

- **recording telemetered data from aircraft and missile test flights**
- **readout from analog computers**
- **checking strain on hydraulic systems: presses, pipelines, controls**
- **recording characteristics of electrical equipment**
- **measuring stress and strain on structures and machines**
- **analyzing performance of equipment and personnel in operational simulators**

Engineers are scarce—so it's wise to use your engineering manpower at top efficiency. Use Brush instrumentation.

For a copy of complete bulletin, Modern Measurements, write Brush Electronics Company, Dept. A-2, 3405 Perkins Ave., Cleveland 14, Ohio

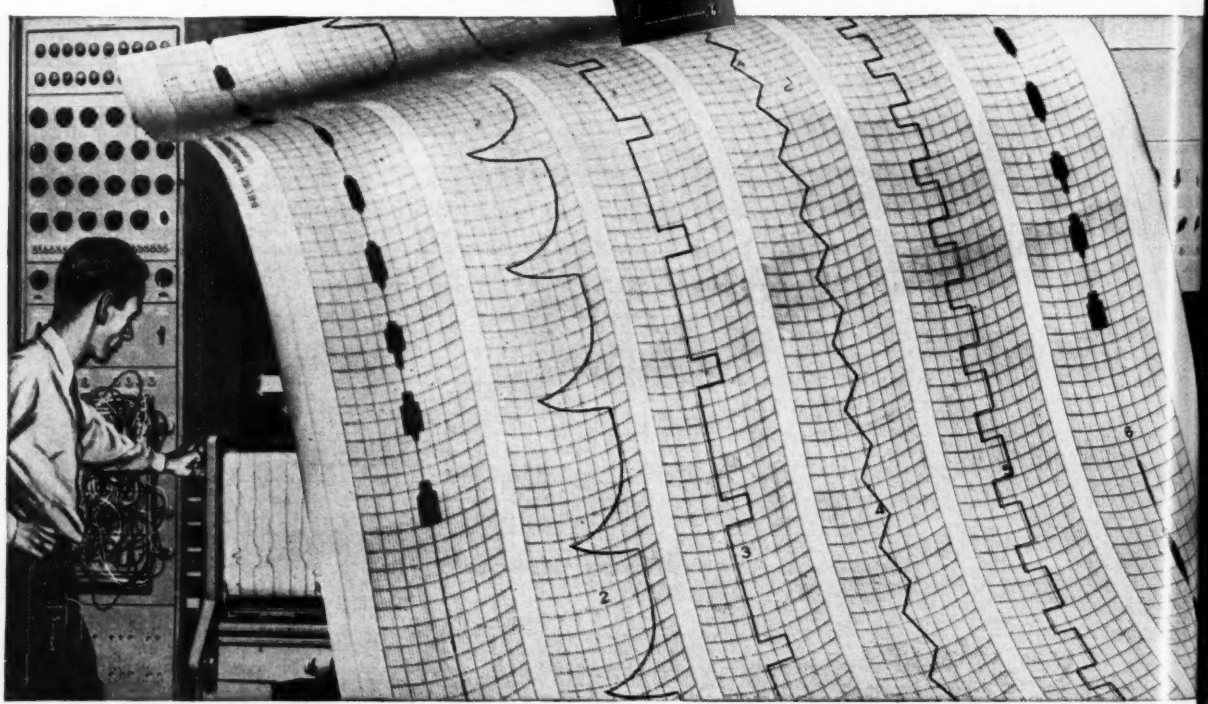


Illustration courtesy Grumman Aircraft Engineering Corporation

IRE SHOW

See Brush Exhibit

Booths 869, 871, 873, 875, Theatre 4

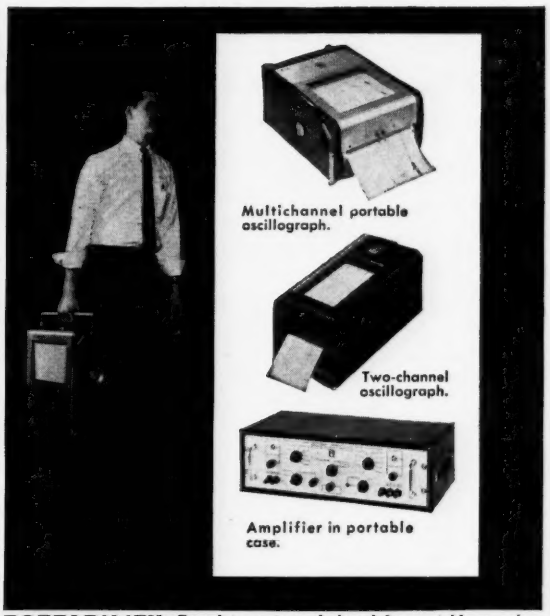
For more information circle **16** on inquiry card.

Look for these features in recording instruments

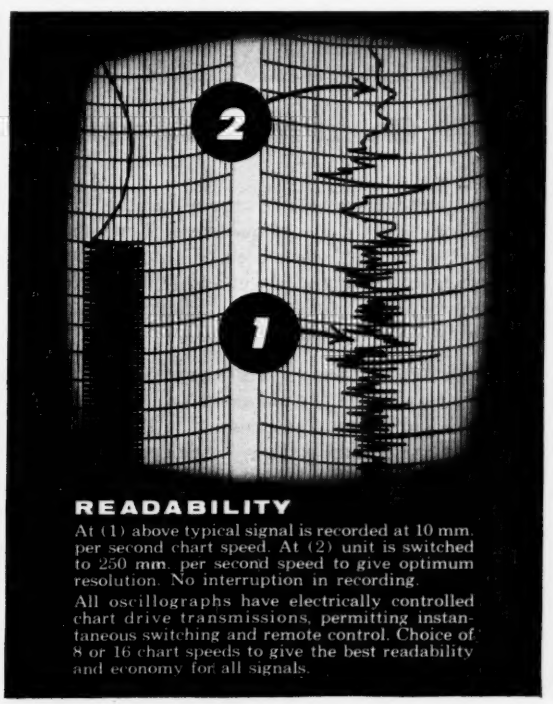
Multichannel oscillograph records variables from d.c. to 100 cycles per second.
Universal* Amplifier for use with both resistive or inductive transducers.
Dual-channel D. C. Amplifier.
D.C. Chopper Stabilized Amplifier, gain of 10,000.

FLEXIBILITY—Four and six channel oscillographs are physically interchangeable. A four channel unit, selected to meet present requirements, can be *expanded* to a six channel unit later. All oscillographs and amplifiers mount in standard 19-inch racks or consoles. Complete selection of amplifiers.

*Trade Mark



PORTABILITY—Complete systems designed for portable use simplify field testing and measurements. Units are light in weight, durable, easy to set up. Typical weights for oscillographs: 2-channel 25 lbs., 4-channel 38 lbs., 6-channel 51 lbs.



READABILITY

At (1) above typical signal is recorded at 10 mm. per second chart speed. At (2) unit is switched to 250 mm. per second speed to give optimum resolution. No interruption in recording.

All oscillographs have electrically controlled chart drive transmissions, permitting instantaneous switching and remote control. Choice of 8 or 16 chart speeds to give the best readability and economy for all signals.

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BRUSH ...*complete systems for noise or vibration measurement*

Carrier keeps cool air quiet

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Brush Sound Measuring systems can help you *analyze and record* noise, vibration, strain and other phenomena in the audio frequency range. The Brush versatile signal source and control systems provide complete facilities for:

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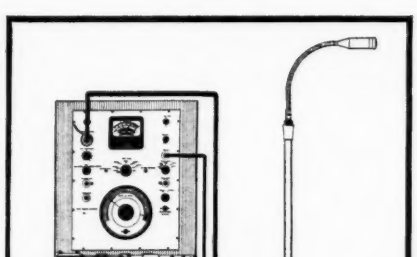
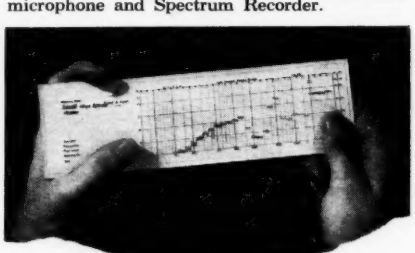
- **Mechanical resonance tests**
- **Excitation and regulation of shaker systems for environmental vibration testing**

Call your nearest Brush representative or write for bulletin "Sound Measurement". Brush Electronics Co., Dept. A-22, 3405 Perkins Avenue, Cleveland 14, Ohio.



Test setup shown requires only a measurement microphone and Spectrum Recorder.



The complete noise spectrum analysis graphically recorded provides immediate, fool-proof and permanent measurement data.

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Panhandle Pete

Listen To The Mocking Bird

RAN into my old friend Clarence Baker who works over at Weirton Steel Company. He was full of ideas that I can write about—mostly controversial topics such as "Why don't so-and-so do something about their busy controllers and why doesn't somebody else fire their chief engineer and hire somebody who knows what he is doing."

"Hell's Fire, Bake," says I, "I can't write about those kinds of things. We'd all get put out of the editor's chair and sued besides. Then we wouldn't have anything to do in the evenings." Then I saw that Baker had a roll chart stuck in his back pocket and one word led to another.

"What's that off of, Bake? Looks like you have a mess of open couples running there?"

"Ah, we put this four-point Model S on one of our open hearth furnaces to get some temperatures and the blamed thing shows readings all over the chart because the furnace reverses, you know how it is. I thought I would save some time and work but this blamed chart has so much stuff on it I can't tell what's going on. We're going to have to run this test all over again but this time I'm going to use two of these meters. No more of this mess!"

"Well, if you are going to do that can I have that chart? My kids can draw pictures on the back of it," says I with a gleam in my eye. I got ideas; nobody is going to draw pictures.

So I bring the chart home and get the kids out and we get busy and make a game out of seeing how many holes we can punch in the chart everyplace the Model S has printed a temperature reading. This kept me and the kids busy all Sunday afternoon. The wife had her first nap in years. When we got all the temperatures punched I took a piano roll and spliced this chart in the center of it and started her through the piano. We listened awhile to some classical music by the Chamber Music Society of Lower Basin Street, namely the *Memphis Blues*, when all at once this temperature chart came along—and out of the piano came "Listen to the Mocking Bird" just as plain as though Haley herself was playing it.

It is unbelievable the vast fortune that is awaiting some ambitious soul who will gather up the miles of charts that industry throws away every day and punch holes through them to see what kind of music comes out. Who knows, you might find a song hit doing this? *Panhandle Pete*

Announcing

PROCESS CONTROL ANALYSIS

by

Millard H. LaJoy and E. Allen Baillif

One of the frontiers of instrumentation and automation is analysis of the closed-loop controlled process to effect maximum efficiency. This requires analysis of the frequency response of the system, including mathematical treatment of the process and its controller elements. The authors of this book have based their treatment on simple representation of the closed-loop system in terms of elementary resistance and capacitance elements. This work represents an essential first step for the control engineer or instrument man who wishes to extend his vision into the field of the frequency response of the closed-loop controlled system.

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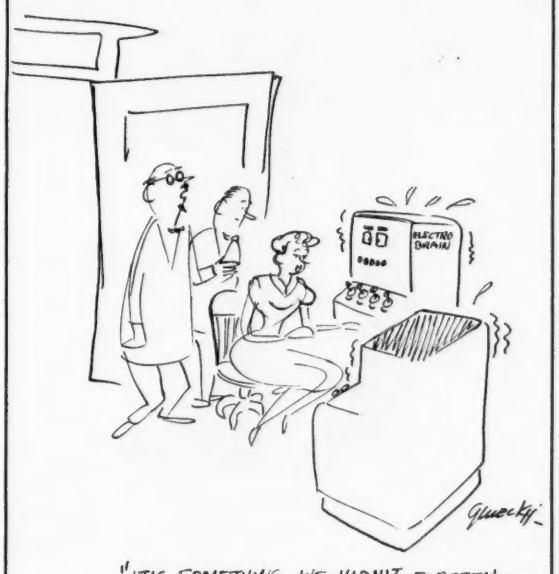
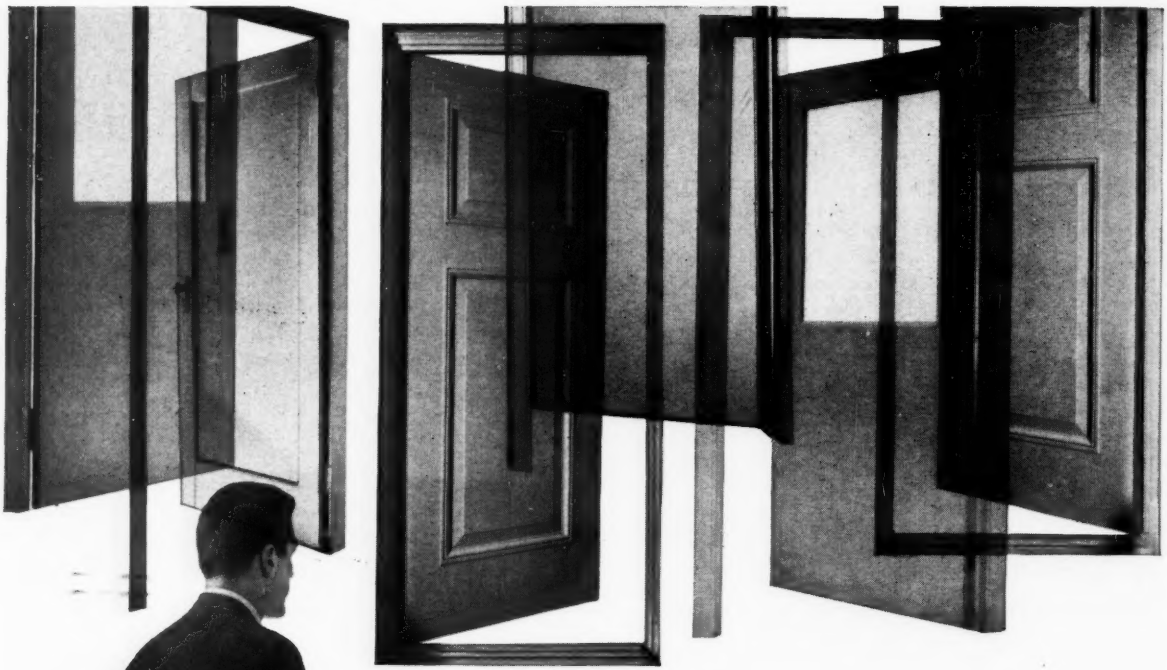


"IT'S SOMETHING WE HADN'T FORSEEN — APPARENTLY IT CAN BE EMOTIONALLY INVOLVED —"



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- **Isolated Input**
- **Low Noise Level**

Write for Bulletin NI-4

THE DOELCAM Magnetik Null Indicator, Model 2HG-1, is *both* a null balance detector and a linear deflection indicator. It may be used as either a low level laboratory instrument where *accurate null* measurement is important, or as a fast measuring production test instrument where *linear* off-balance readings and ability to withstand rough usage are essential. All around improved performance is achieved by use of the unique DOELCAM Second-Harmonic Magnetic Converter as the input modulator.

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PROPORTIONAL DEFLECTION: Linearity over full scale range is within 5% accuracy.

ISOLATED INPUT: Input terminals are isolated from chassis and circuit ground.

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INSTRUMENTS and AUTOMATION News

Principles & Applications ....220 to 230
Stock Report 230
New Plants & Mergers .....235 to 236
People in the News .....241 to 244

NBS Preferred Circuit Program

WASHINGTON, D. C.—The National Bureau of Standards, in cooperation with the Navy Bureau of Aeronautics and with the aid of industrial groups, has embarked on a program to simplify and standardize basic circuits. Subcircuits, such as rectifier, amplifier, timing and other circuits, form a great part of the complex overall circuits necessary for aeronautical electronic equipment. Considerable savings in costs, manhours, delivery, etc. can be brought about if standard circuits are available which can be used in their place.

Detailed examination of 22 carefully selected items of aeronautical electronic equipment resulted in identification of 64 basic and typical circuits, which are reported in the *Handbook of Preferred Circuits for Navy Aeronautical Electronic Equipment*, NavAer 16-1-519 (which will be available from the GPO after February 20, 1956).

Electronic Banking

NEW YORK, N. Y.—Closed circuit television equipment supplied by General Precision Laboratory, using microwave transmission and individual screens at each

teller's window verify signature and account balance with the teller never having to take an extra step from his post. The bank expects TV and its new National Cash Register accounting machinery to provide facilities for an increase in deposits of 333% with a mere 25% increase in equipment and personnel.

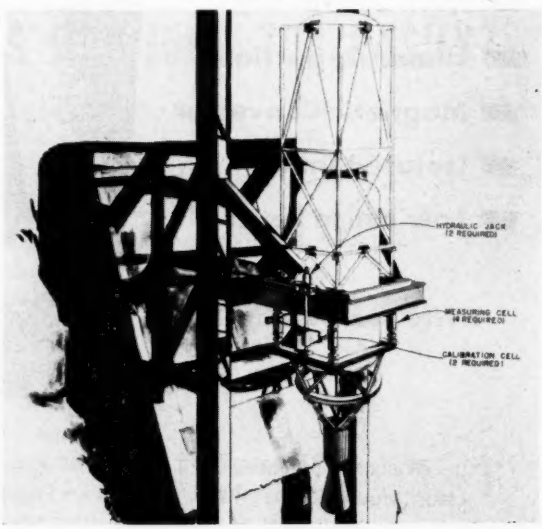
Mutual Inductance Transducers

WASHINGTON, D. C.—Since the mutual inductance transducer was originally developed by M. L. Greenough of the National Bureau of Standards, the device has found increasing application in electronic distance measuring instruments, including electronic micrometers, manometers, oil film thickness indicators, vibration pickup calibrators, and others. There has been a growing need for general design criteria for use in future applications.

H. M. Joseph and N. Newman of the Bureau's electronic instrumentation laboratory have made a detailed study of the device's operating principles with major emphasis on transducers using highly conducting reference plates. The results include a number of design recommendations for obtaining optimum combinations of stability, sensitivity, and linearity over the range in which the instrument is to be used.

Thrust Measurement

PHILADELPHIA, PA.—For the measurement of thrusts by various types of rocket motors and fuels at White Sand Proving Ground, four Baldwin-Lima-Hamil-



ton load cells are used at the corners of the rocket thrust mount and two calibration cells on opposite sides of the frame. The four thrust measuring cells are connected to a recorder, and the two calibration cells to a precision indicator. Indicator ranges are 0-100,000 and 0-200,000 lb.

Impact of Automation

ST. LOUIS, MO.—On January 5, 1956, Richard Rimbach, publisher of INSTRUMENTS and AUTOMATION and manager of the several Automation Expositions, addressed The Engineer's Club of St. Louis on the subject "Automation and its Impact on Industry." His talk defined the field, its principal places of application, its impact on the economy, and the automation outlook. More than 200 professional engineers turned out for the definitive presentation.

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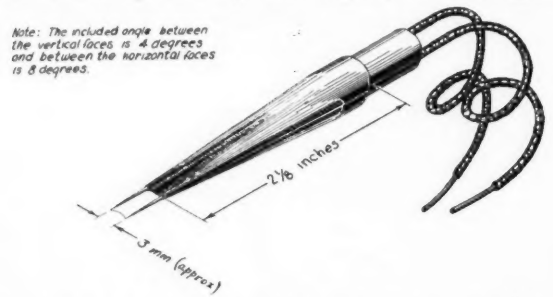
Supersonic-Flow Anemometer

WASHINGTON, D. C.—As-yet there is no well defined method for studying turbulence at air speeds exceeding that of sound. Seeking to extend the range of the hot-wire anemometer into the supersonic region, W. G. Spangen-


Note: The included angle between the vertical faces is 4 degrees and between the horizontal faces is 8 degrees.
2⅛ inches
3 mm (approx)

berg of the National Bureau of Standards recently made a study of the behavior characteristics of this instrument at air speeds up to twice the speed of sound. In the final design adopted, the heated wire was attached to the ends of two honed sewing needles, 0.018-inch in diameter, butt-brazed to electrical leads embedded in hard rubber.

Evaluation of the heat loss from the wires required accurate measurement of wire resistance and current. The results of the Bureau's investigation indicate that in contrast to an accepted theory, the heated wires respond differently to each of the factors contributing to the rates of cooling, such as velocity and density of the air and the temperature and diameter of the wire, so that no simple relationship can be established.

While evidence of the versatility of this instrument was established, studies of the hot-wire anemometer in the supersonic range are continuing at the Bureau.

Pittsburgh Conferences of National Stature

PITTSBURGH, PA.—The Analytical Chemistry Group of the Pittsburgh Section of the American Chemical Society, and the Spectroscopy Society of Pittsburgh will be hosts for the Seventh Pittsburgh Conference on Analytical Chemistry and Applied Spectroscopy which will run in the William Penn Hotel from Monday, February 27, 1956 through Friday, March 2, 1956. With 188 papers in the respective fields it will be the largest Analytical Conference ever held. An Exposition of laboratory equipment will be held simultaneously.

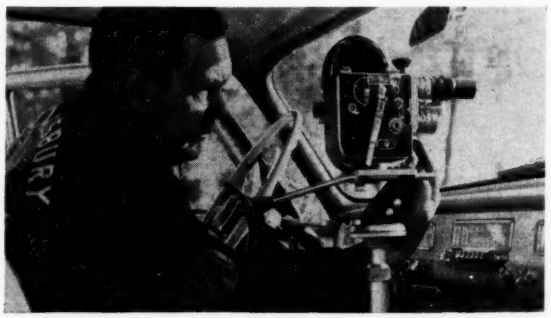
Instrumentation for the Iron and Steel Industry is the theme of the ISA Pittsburgh Section's Sixth Conference, scheduled for March 5 and 6, 1956 in the Hotel Webster Hall. The papers read at its predecessors have established its national reputation. This year's papers are on the same high level. Advance reservations for the three-day companion-exhibit (March 5, 6, and 7, 1956), at the same location, required expanding into an adjoining room and promises to top all previous attendance records.

Cleveland Electronics Conference

CLEVELAND, OHIO—March 2 and 3, 1956 are the dates for Cleveland's Third Annual Electronics Conference. The Old Gymnasium of the Western Reserve University is to be the place. The IRE, AIEE, ISA sponsor it jointly with the Cleveland Physics Society, Western Reserve University, and Case Institute of Technology. Technical papers to be presented include: Measuring Low Currents in Industry (Keithley Instrument Co.), Development and Application of Ruggedized Sealed Meter Relays (Assembly Products Co.), Some Applications of Radiation Detectors (Victoreen Instrument Co.), Industrial High Gain Amplifiers (Clevite Research Center), Color Television Test Equipment (Hickok Electric Instrument), An Automatic Boiler Level Control System for Nuclear Submarines (Swartwout Co.), Application of Electronic Analog Computing Equipment (Goodyear Aircraft Corp.), and others; 17 companies will show appropriate exhibits.

Autopod Camera Support

PASADENA, CALIF.—A convertible camera support, being marketed by Jewitt Mfg. Co., 201 Del Mar Place,



San Gabriel, Calif., permits motion picture camera to shoot pictures through windshield for evidence, record, performance, study, etc.

New Industrial TV Transmits on Ordinary Telephone Lines

PHILADELPHIA, PA.—Closed circuit TV now can utilize ordinary telephone wires as a demonstration (staged jointly by Bell Telephone Co. of Pennsylvania and Dage Television Division, Thompson Products, Inc., Michigan City, Indiana) proved. Data-Vision was used by the Philadelphia National Bank between two offices located 10 blocks apart to prove its value in signature verification. In contrast to ordinary industrial TV, which requires a 4-Mc band, Data-Vision requires only 8,000-cycle bandwidth. Present limitations of the system are 25 miles, with work going on to extend the range.

Fellowship Grant Assists Computer Research

PITTSBURGH, PA.—Carnegie Tech has averaged one out of every 12 doctorates in electrical engineering in the nation. Analog-computer research is high on the list. and has been supported by agencies of the Defense Department. CARL, the Carnegie Automatic Root Locator, is one of the results of these endeavors. A private grant of $10,000 for four scholarships was recently made to the school by an alumnus, the owner of the L. A. Terpening Co. of 16 W. 61st St., New York 23, N. Y., which will enable the grantee to devote full time to research and study, and be rewarded by a doctor's degree.

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For more information circle **22** on inquiry card.

NEWS—CONTINUED

Transient Instrumentation

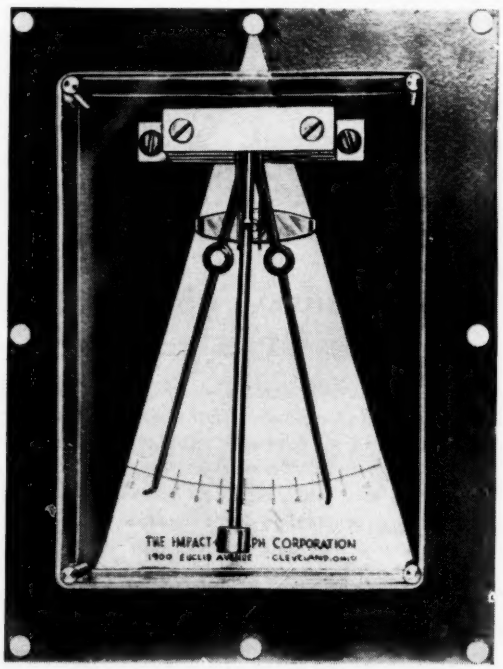
PASADENA, CALIF.—An effective instrument system for recording elusive transients with rise times in the 80-microsecond range is provided by a new 20-kc

carrier amplifier, and additional equipment, made by Consolidated Electrodynamics Corporation, Pasadena, Calif. The system includes the firm's new Type 1-127 carrier amplifier, Type 7-326 galvanometers, Type 5-114 recording oscillograph, and Type 5-006 high-speed magazine.

Applications include blast-pressure recording, studies on air compressors, measurement of high-frequency mechanical vibrations, hydraulic-system transient studies, and measurements on internal combustion engines during high-speed operation.

Minimizing Damage in Transit

PHILA., PA.—Pennsylvania Railroad has an extensive campaign underway to minimize damage to material in transit. Latest move has been the ordering of more than a hundred of these small indicators that give an order of magnitude of the acceleration suffered by a freight car. The instrument is mounted on the side of a freight car. The pendulum-type mass can swing sideways, but is restrained by elastic members shown at the top of the unit. The force due to acceleration of the mass (and freight car) moves the indicators which are cali-



For research . . . for quality control . . . for raw material inspection —

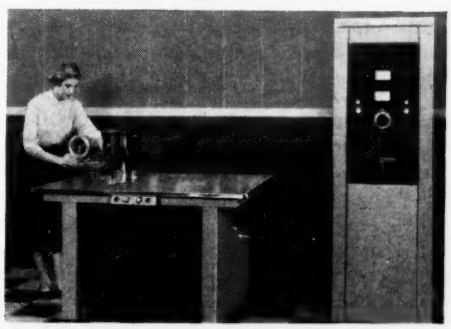
New G-E x-ray diffraction unit fits any analysis program

FOR fast, accurate qualitative or quantitative analysis of solids or liquids, the General Electric XRD-5 offers a host of new advantages.

New versatility! Basic components allow you to start with high-standard minimum equipment . . . add features as needs grow. Double duty! Twin-tube operation achieved simply by adding a second tube and ma control. New accessories! A full range of new accessories enables users to fully exploit the advantages offered by diffraction and emission technics.

The XRD-5 works equally well when analyzing large or minute samples. As for speed, one research laboratory cut its time on a product identification test from two days to five minutes—one half of one percent of the time formerly required by conventional chemical analysis.

For complete information on the XRD-5, consult your G-E x-ray representative. Or write X-Ray Department, General Electric Company, Milwaukee 1, Wisconsin for Pub. BL-24.



General Electric diffraction unit equipped for minimum film technics. Added equipment (additional tube, shockproof case, and ma selector) provides facilities for up to six instruments at one time. Further additions will equip the unit for simultaneous film- and direct-measurement technics.

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Manufacturers of the only compete x-ray line

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THE MARK OF QUALITY

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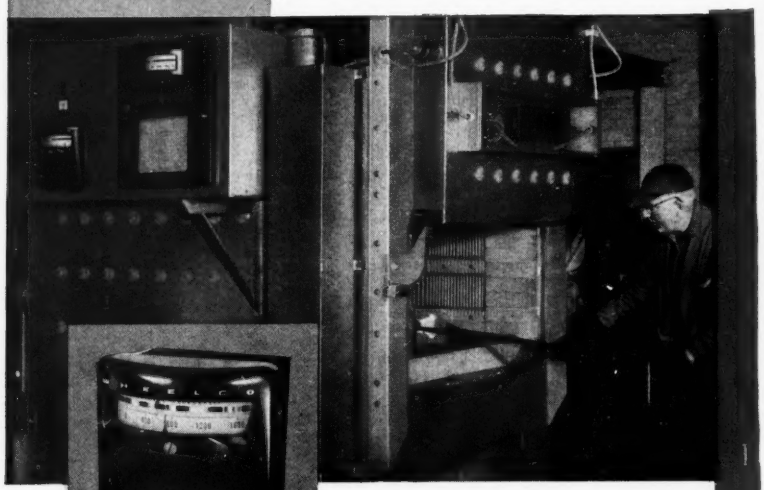
Wheelco Instruments

Model 407 Capacitrol improves furnace control, lengthens service life of heating elements



Wheelco's Model 407 Capacitrol, with saturable core reactor, improves heat treat results and reduces equipment maintenance at Rockford Drop Forge Co., Rockford, Ill. Stepless, proportioning control of power input to an 80 kva Hevi-duty electric furnace gives even, straight-line heating, without lag or overshoot, for heat treating, annealing, and carburizing operations.

Forging hammer dies are hardened to saturation at 1850° F with improved results over the on-off control formerly used. Uniform hardening possible with Wheelco control has eliminated cracking and splitting when dies are oil quenched after heating. An added benefit of proportioning control is elimination of contactor troubles caused by on-off cycling. Also, saturable core reactor control will not permit the furnace to overshoot its control point, a major cause of damage to heating elements.

Perhaps your problems of electric furnace control can be solved by this remarkable new instrument. Call your Wheelco field engineer to get the benefit of Wheelco's long experience in control of heat processing equipment.

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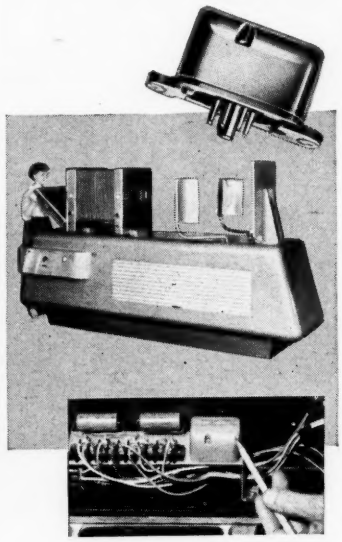
ultra-sensitive relays

chosen to assure fine focusing of ATF Mastercraft Camera



The new Mastercraft camera of American Type Founders, Elizabeth, New Jersey, embodies many new, advanced automatic operating principles. A major one of these is the precision focusing feature which lets the operator "dial in" the exact enlargement or reduction desired. In this focusing circuit a Barber-Colman Micropositioner is used. In your products, too, there is very likely a place where you can make good use of this remarkable ultra-sensitive relay. Various types...plug in, solder-lug, screw terminal, hermetically sealed. Operate on input powers of 50 to 1,000 microwatts. Ideal for use as a null detector in resistance bridge circuits, a differential relay in electronic plate circuits, and an amplifier in photoelectric circuits. Can be operated in excess of 100 cps. Write for Bulletin F-3961-4.

Barber-Colman Company,
Dept. B, 1415 Rock Street, Rockford, Illinois

For more information circle 25 on inquiry card.

brated in miles per hour—the speed the train was moving when stopped by collision. Trainmen can see for themselves how carefully the car was handled. The indicator instrument was made by The Impact-O-Graph Corp., 1900 Euclid Ave., Cleveland, Ohio.

New Bendix General-Purpose Computer Revealed

CHICAGO, ILL.—The Computer Division of Bendix Aviation Corp., Los Angeles, made the Second International Automation Show the place for the first public showing of its new G-15A, a model of which has been in operation for sometime at the Bonneville Power Administration's power dispatching center in Portland, Oregon. Its job there is to make intricate calculations relating stream flow and reservoir storage to power generation and transmissions operations. After all installations are completed it will assure maximum efficiency of output of some 5,268,700 kilowatts.

Another important application is with an unrevealed oil-producing company where it is used to evaluate earth strata and reservoir statistics in the search for new oil deposits, as well as seismic, refining, and distribution data.

The computer has a magnetic drum capable of storing 2,000 eight-digit words and does not take up more space than 2 filing cabinets.

News Bits

AN OVERLOAD PRESS CONTROL for a 50,000-ton closed-die forging press has been developed by Clevite Research Center.

ENVIRONMENTAL TEST CHAMBER of unusual design (upswinging door is operated by air cylinder) has been designed by American Research Corporation for application where door had insufficient room for swinging open in conventional manner.

LEEDS & NORTHRUP have received a contract for the complete control system from Foster Wheeler Corp., prime contractors for the 1000-kw Livermoore pool-type reactor at the University of California.

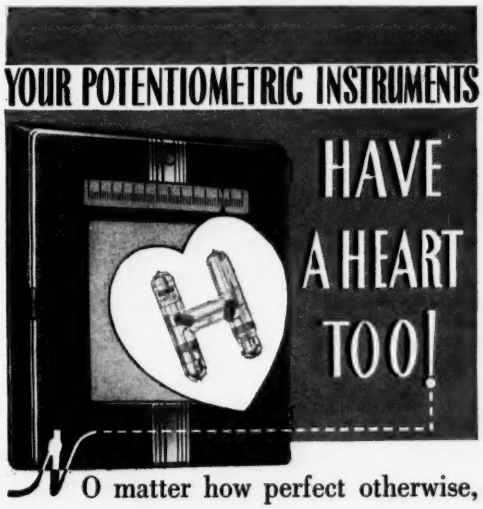
MARTY LADDEN'S Training School for M-H's Industrial Division, reports a record-setting class of 41 engineers and technicians (including students of 7 foreign firms).

FEDERAL PRODUCTS CORP. has marketed a radial-and-lateral runout gage on a fully-automated continuous line where tubeless-tire wheels are produced at a rate of 900 per hour. If the tolerances are exceeded the wheel is dropped through a trap door.

AN UNBALANCED-WEIGHT TESTER for checking miniature ball-bearing torque has been devised by Lear, Inc. for Miniature Ball Bearings, Inc. and Minneapolis-Honeywell.

THE U. S. DEPT. OF COMMERCE, Office of Technical Services, has released Report PB111777 on a vibration exciter in the 10-to-30-kc range for testing stresses in jet-engine blading.

UNION SWITCH AND SIGNAL DIV. of Westinghouse Air Brake Co. devised controls for a **NEW HAVEN R. R.** commuter car which recently proved in



NO matter how perfect otherwise, the human organism isn't much good without a dependable heart. The same is true of your automatic temperature and pH control instruments.

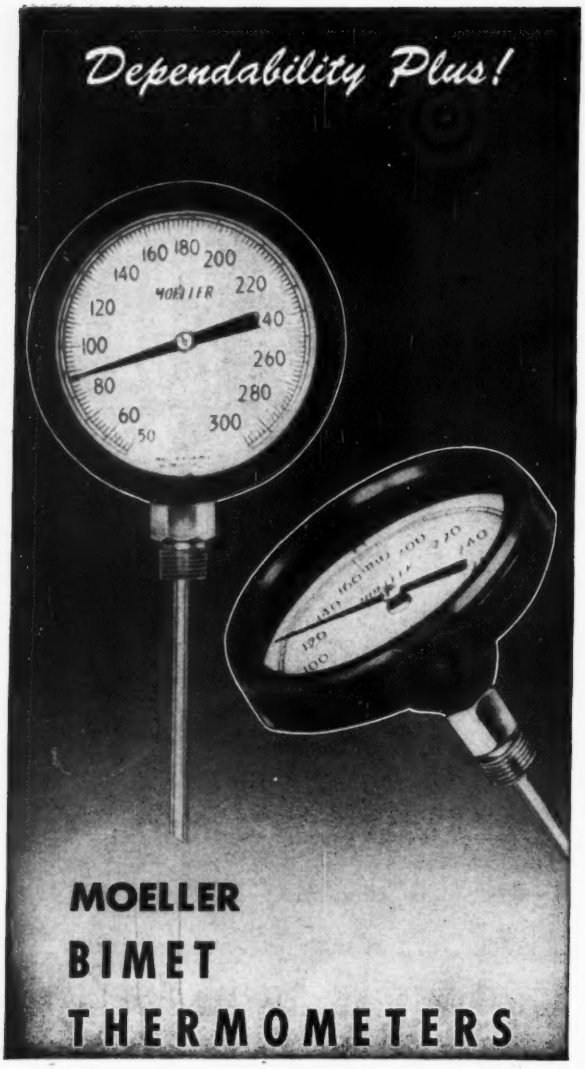
The "heart" of most such instruments for the past quarter century has been the Eplab Standard Cell. It is a "yardstick" for translation of voltage to temperature or pH. The first American commercial cell of its type, constantly improved by research, it is "as standard as sterling".

Get ACCURATE temperature or pH control with potentiometers and make sure the standard cells are EPLAB.

The Eppley Laboratory, Inc. 2 Sheffield Ave., Newport, R. I.

EPLAB *Standard* CELLS
FOR POTENTIOMETRIC INSTRUMENTS
"As Standard as Sterling"

For more information circle **26** on inquiry card.



No doubts, no indecisions . . . When you need accuracy most and want to know that you can absolutely rely on correct, accurate readings, Moeller Bimet Thermometers live up to their reputation for dependability.

Sturdy mechanisms enclosed in durable cases guarantee continued top performance.

MOELLER INSTRUMENT COMPANY 132nd ST. and 89th AVE. RICHMOND HILL 18, N. Y.
Representatives in Principal Cities

Gentlemen: Without obligation, please send me Moeller Bimet Thermometer Bulletin No. 225 B.

NAME .....
FIRM .....
ADDRESS .....
CITY ..... ZONE..... STATE.....

For more information circle **27** on inquiry card.

NEWS—CONTINUED

an 11-mile trial run that trains can be operated by remote control from a central station, much like toy trains.

10,000-HP, 400-RPM DYNAMOMETER, called the West's largest hydraulic test machine, was recently put in operation by Enterprise Engine & Machinery Co. for its new 12- and 16-cylinder diesel engines.

SECOND IBM 650 COMPUTER is now used at Jones & Laughlin Steel Corp. for processing the payroll of its employees.

EDIS, MINNEAPOLIS-HONEYWELL'S electronic data integrating system, is believed a "first" in combining computing and quality evaluation with automatic data-handling. Cost ranges from $10,000 to $50,000. Esso's Bayway refinery owns this new equipment.

IBM TYPE 704 COMPUTER will be in the new MIT Karl Taylor Compton Memorial Laboratories when it opens in 1957.

THE NATIONAL BUREAU OF STANDARDS publishes its intention to abandon the master Saybolt Viscometers in favor of the ASTM std. conversion tables. Objections to this move should be filed before June 30, 1956.

CONSOLIDATED ELECTRODYNAMICS CORP. reports that use of a CEC Spectrometer at a sulfur recovery plant resulted in 1.2 tons/day increase in sulfur production—with less smog.

AMERICAN INSTITUTE OF MANAGEMENT has certified five companies prominent in the instruments field as being "Excellently Managed." Those named are Minneapolis-Honeywell Regulator Co., Square D Co., Sperry-Rand Corp., Rockwell Mfg. Co., and Elgin National Watch Co.

REMINGTON RAND UNIVAC DIVISION will install a complete Computing Center and integrated computation exhibit, at Franklin Institute in Philadelphia.

THE NATIONAL BUREAU OF STANDARDS has established an information service for technical data on both domestic and foreign radio tubes. Nearly 10,000 cards are filed by tube type number. About 10 percent of these cards, covering mainly miniature and subminiature types, have been coded on punched cards for mechanical sorting.

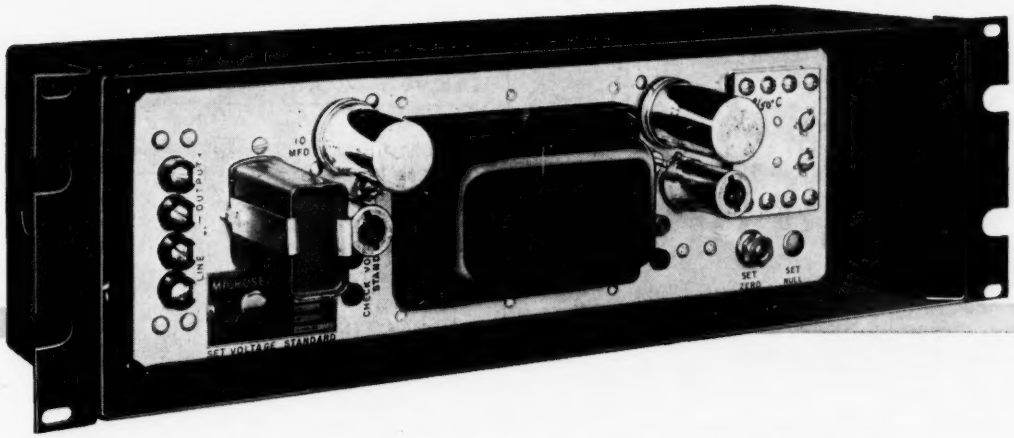
DUMONT'S INDUSTRIAL TV safeguards the giant forging press at Alcoa's Cleveland Works, preventing off-center loading of the 35,000-ton unit.

MINIATURE PRECISION BEARINGS, INC., by supplying miniature pivot bearings, raised the maximum torque limit on Brabender's Plastograph (placticity meter) by 100%.

JUNCTION TETRODE TRANSISTORS, in the experimental stage at Bell Telephone Laboratories, have generated oscillations above 1000 Mc.

GE'S RADIATION PRESSURE FLOAT is a new device for measuring acoustic power output of ultrasonic generators. It establishes a standard which will help evaluate ultrasonic devices.

ATOM SMASHING techniques are now descending to bore holes of great depth. Miniature Van de Graff accelerators, made by High Voltage Engineering Corp., are incorporated in standard logging assemblies by Wells Surveys, Inc. to set up nuclear reactions in the surround-



NEW TRANSMITTING POTENTIOMETER OFFERS 7 BIG FEATURES

★ **Extreme sensitivity. Responds to input change of 3 microvolts or less.**

★ **Self-contained continuous voltage reference. No standard cells.**

★ **No batteries or periodic standardization. Continuous accuracy without drift.**

★ **Simple circuitry. Only 2 single triode tubes.**

★ **Interchangeable range card. Ranges easily changed in the field.**

★ **No slide wires or choppers. Trouble-free operation.**

★ **Fast response: 0.04 second time-constant for 1000° F. span.**

The Series 184 Transmitting Potentiometer is the latest addition to the 'American-Microsen' System of Electronic Transmission and Process Control. With this new unit, it is now possible to measure and control thermocouple temperatures or the signals from such devices as pH amplifiers, gas analyzers, resistance thermometer elements, and other electrical systems.

The extreme sensitivity of the new Potentiometer, plus the high resolution and response speed of the 'American-Microsen' Control System, makes it possible to control process temperatures with the high accuracy required by present-day production demands.

The 0.5 to 5.0 ma. signal output can be transmitted 30 miles or more, over a single 2-wire circuit. In addition to 'American-Microsen' receiver, the signal will operate standard d-c milliammeter indicators and recorders.

OPERATING SPECIFICATIONS

Spans: 6 to 50 millivolts d-c.
Suppression: Up to 5 times span.
Output Signal: 0.5 to 5.0 ma. d-c.
Sensitivity: 0.003 millivolts (0.1° F.).
Repeatability: 0.02 millivolts. (0.6° F.).
Input Source Impedance: 200 ohms maximum.
Effective Input Impedance: 1000 ohms per millivolt of span.
Output Load Impedance: 3000 ohms maximum.
Speed of Response: 0.8 seconds for 99% response on 6 millivolt span. Speed increases with span.

Write today for Bulletin MTT810.

MANNING, MAXWELL & MOORE, INC.

INDUSTRIAL CONTROLS DIVISION, STRATFORD, CONNECTICUT

MAKERS OF THE 'AMERICAN-MICROSEN' TRANSMISSION AND PROCESS CONTROL SYSTEM, 'AMERICAN-MICROSEN' ELECTRO-PNEUMATIC TRANSDUCERS AND ELECTRO-HYDRAULIC CONTROL VALVE OPERATORS.

MAXWELL MANNING M&M & MOORE INC. TRADE MARK

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COMPRESSED AIR AND GAS COME OUT OF THE LOGAN

ARIDIFIER

Scrubbed CLEAN AND DRY

INSTALL ARIDIFIERS ON LINES SERVING

- Paint Spray Guns
- Air Tools
- Air Hoists
- Foundry Jolting Machines
- Sand Blasting Tools
- Sand Blasting Rooms
- Metal Spray Guns . . . or Wherever the line must deliver clean, dry air or gas

On any air or gas line 92% of the dirt, oil, scale and water that enter the Aridifier is trapped and removed from circulation. The Aridifier's patented centrifugal-baffle action scrubs air and gas clean and dry . . . protects equipment, prevents freezing, fouling, corrosion and caking, produces best results with spray gun and air tool operations, etc. Easy to install. Self cleaning. Maintains itself. 10 models available. Capacity 7 CFM to 17,000 CFM.

Learn HOW the Aridifier scrubs with a patented centrifugal-baffle action.

Write for This Catalog Now!

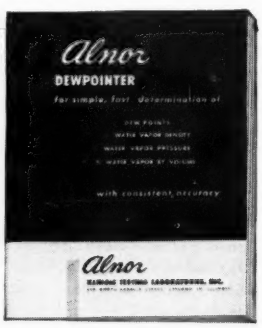
Logan ENGINEERING CO.
4921 W. Lawrence Ave., Chicago 30, Ill.

For more information circle **29** on inquiry card.

get this **free** INFORMATIVE BULLETIN

Learn how easy it is for anyone to determine dew points quickly and accurately with the

ALNOR DEWPOINTER!



Only the Alnor Dewpointer has a sealed testing chamber, where atmospheres can be analyzed under controlled conditions . . . where the fog is observed *suspended in air* for fast, positive readings. Completely self-contained and readily portable for laboratory accuracy anywhere in the plant or field. And simple, direct operation enables even nontechnical personnel to easily obtain precise results, time after time.

Tear out this ad and send it along with your business letterhead to Illinois Testing Laboratories, Room 518, 420 N. LaSalle St., Chicago 10, Ill.

Alnor

PRECISION INSTRUMENTS FOR EVERY INDUSTRY

For more information circle **30** on inquiry card.

NEWS—CONTINUED

ing formations. Information gleaned by radiation detection equipment forms the clue whether or not oil can be found in the strata.

DU MONT CLOSED-CIRCUIT TV has made a hit with three quarters of a million Ethiopians at their Silver Jubilee Fair, and won a gold medal from the Negus for the U. S. pavilion.

REMINGTON-RAND, Division of Sperry Rand Corp. has donated an ERA 1101 high-speed, general purpose computer worth about $1\frac{1}{2}$ million to Georgia Tech's one-year-old Rich Electronic Computer Center to further the school's efforts to educate specialists for computer operation.

ARMENIAN LANGUAGE is one of 50 languages that can be typed on the new "50-Language Vari-typer" designed by Coxhead, Newark, N. J., for the U. S. Army and operated by a G. I. who cannot distinguish Armenian from Adam. He simply strikes the keys according to a numerical sequence of a message set up by a linguist.

CRASH AND FIREPROOF RYAN FLIGHT RECORDER built by General Mills, preserving all pertinent data of flight, may become compulsory equipment on all aircraft.

Stock Report

The following prices and price ranges are supplied by Bache & Co., 36 Wall Street, New York 5, New York

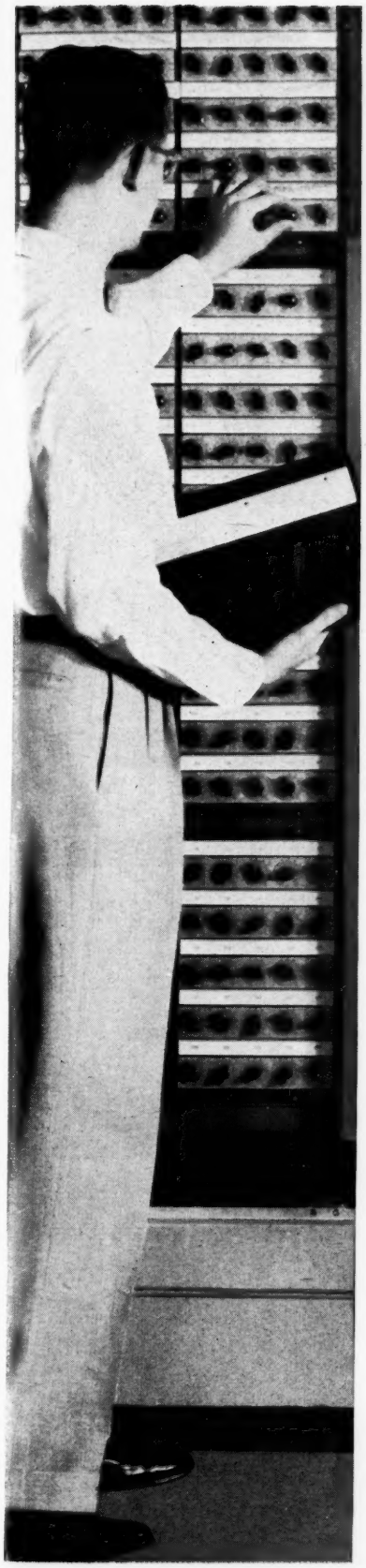
New York Stock Exchange:

Security	Price Range for Year Thru December 30 High	Low	As of December 30 Last
Aeroquip Corp.	17 1/2	8 1/2	13 3/4
American Chain & Cable	46 3/8	35 1/2	41 3/8
American Mach. & F.	35 7/8	23 1/4	26 5/8
American Mach. & M.	41 3/8	27 1/2	37 1/4
American Optical	53 1/4	38	39 1/2
Beekman Inst.	29 3/8	19 3/8	28 3/4
Bell & Howell	42 1/4	30 1/2	33
Bendix Aviation	59 1/2	45	57 3/8
Bulova Watch	25 3/8	21 3/8	21 3/8
Burroughs	34 1/4	22 7/8	31
Clevite	25 3/8	20 1/2	24
Dobeckmun	38 7/8	30 1/4	33 1/2
Gamewell	39	27 7/8	28
General Inst.	13	7 5/8	9
General Prec.	71 1/2	36 1/2	47 3/4
General Time	39 3/4	31	31 1/4
Hamilton Watch	25 1/4	18 1/4	21 1/4
International Business Mach.	450	349	403
Minneapolis-Hon.	70	50 1/8	65
National Cash Reg.	47	33 7/8	37
Radio Corp.	55 3/8	36 3/4	47 1/8
Raytheon	25 3/4	13 7/8	18 1/2
Robertshaw-F.	33 5/8	26 1/2	28
Sangano Electric	32	25 1/2	32
Sperry Rand	29 5/8	21	27 3/8
Square D	55 1/4	40 1/2	52 1/4
L. S. Starrett	50	49 3/4	45 1/8
Sylvania Elec.	49 7/8	41	45 5/8
Telautograph	37 1/2	25 1/2	29 1/2
Texas Inst.	16 7/8	10 1/8	13 1/2
Underwood	43 1/8	33	36 3/8

American Stock Exchange:

Security	Price Range for Year Thru December 30 High	Low	As of December 30 Last
Air Assoc.	12 3/4	7 3/4	9 7/8
American Meter	40	32	38 3/4
Benrus Watch	10 7/8	9 3/8	9 5/8
Breeze Corp.	9 3/8	5 3/4	6 3/4
Consolidated Electrodynamics (2)	31 1/4	20	24 3/4
DuMont Labs.	17 1/8	9 1/8	9 3/4
ElectroData	17 7/8	10 3/8	14 7/8
Fairchild, C. & I.	37 1/4	21	23 3/4
Int'l Resistance	12 3/8	5	7 5/8
Lear Inc.	13 3/8	7 1/4	8 1/4
Nat'l Res. Corp.	33 1/4	17 3/8	19 1/2
Neptune Meter	34 7/8	21	34 1/2
New Haven Clock	4 1/8	2 1/4	3 3/8
Norden-Ketay	19 1/2	11 3/8	14 3/4
Pneumatic Scale	31	26 1/2	27 1/4 - 28 1/2 (1)
Servomechanisms	13 3/8	8 1/4	8 3/4
Wallace & Tiernan	26 7/8	19 1/2	21 7/8
Waltham Watch	2 7/8	1 3/8	1 7/8

(1) Bid - Ask price, no sale.



Panalog Information Systems guide management in raising plant output and profit

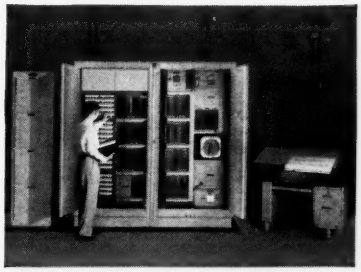
Panalog 605 Information System supplies management control information. Now, operating personnel and management can receive organized digital information on any process, instantly and continuously. Information can be presented in a variety of forms for immediate control action as well as for engineering and accounting analysis. A typical presentation method employs an electric typewriter and patented log chart. Readout can also be made on punched or magnetic tape, punched cards, or can be fed directly to computers.

Periodically logs and continuously scans. A precision servo measuring system quantizes process variables during automatic, periodic logging. A high-speed electronic measuring system detects off-normal conditions during continuous scanning of all variables. Normal and return-to-normal values are printed in black—off-normals in red. A complete log of all variables as well as a summary of off-normals can be made at any time.

Completely flexible and expandable. Panalog components are standardized, packaged modules. The system can be easily expanded or modified in the field. The Panalog 605 is sufficiently flexible to supply digital information for any management requirement.

Write for literature. Literature presenting a comprehensive treatment of the Panalog 605 is available. If you wish, a Panellit representative in your area will be happy to discuss the possibilities that a Panalog Information System offers your company.

Full scale, adjustable, high and low off-normal limits are provided for each input variable. Basic system capacity, 200 points with one electric typewriter — can be expanded. Accuracy, ±.25% of full scale range. Logging speed, approximately one line per minute. Scanning speed, five points per second, between logs.



Logged values are grouped by processing unit on chart. Audio-visual alarms accompany detection of off-normals. When scanning, off-normal values are identified and printed in separate chart area. Totalized and averaged values as well as plant efficiencies can be automatically computed and recorded by the system.

U.S. Pat. No. 2,701,748

Engineered Information Systems For Industry

Graphic Panels Control Centers

Panalarm Annunciators

Instrument Services Division

PANELLIT

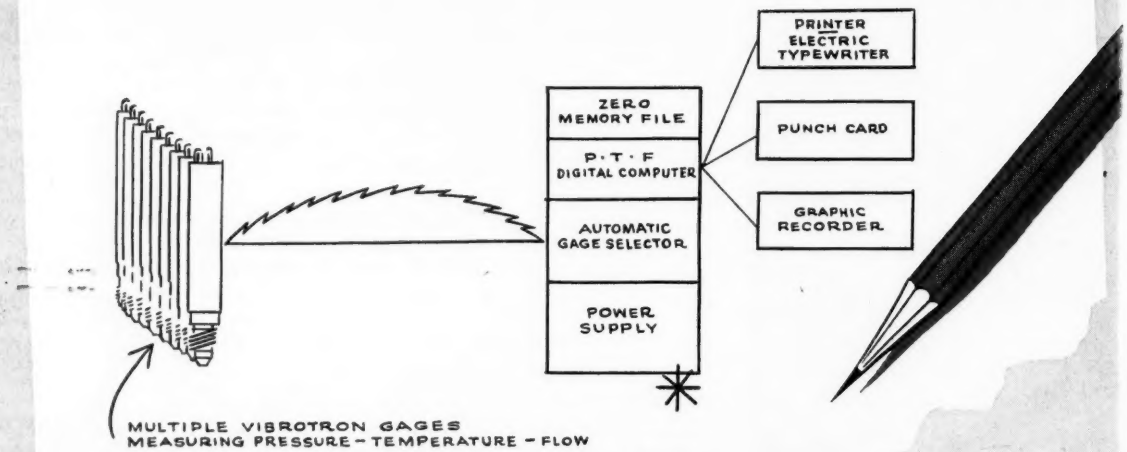
PANELLIT, INC.

7405 N. Hamlin Ave., Skokie, Ill.

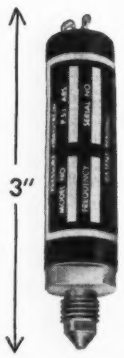
Panellit of Canada Ltd., Toronto 14

For more information circle **31** on inquiry card.

Make your system COUNT!



BJ DIGITAL SYSTEMS



Model 101 Vibrotron

INDICATE, RECORD AND CONTROL pressure, temperature and flow with BJ Digital Systems. It's as simple as 1-2-3. ONE, BJ Vibrotron Digital Gages at remote points use frequency changes to measure pressure, temperature or flow (P-T-F) and signal this information by direct wire or radio link. Two, these frequency signals are received and directly indicated in numbers on the BJ P-T-F Digital Computer without further translation. THREE, this information in numbers can then be fed to any desired recording device or used to initiate control action and close the loop.

Only digital systems give you the direct simplicity of information in *percentage* by numbers from 000 to 999. Thus, all information has a common denominator. Variations in performance are *counted* and not compared.

The heart of BJ digital systems is the BJ Vibrotron Gage which uses a vibrating wire under tension. Pressure, temperature and flow control the tension and frequency signal.

Other Byron Jackson digital system components include: a Zero Memory File which permits simple electronic calibration of all sensing gages in the system; and an Automatic Gage Selector which sequentially selects signals from any number of gages for measurement by the P-T-F Digital Computer.

Investigate BJ digital equipment before you make a decision on your systems problem. BJ electronic engineers are ready to help you make your system *count*.

Send for special technical data file on "Make Your System Count."

BJ

Byron Jackson

DIVISION OF BORG-WARNER CORPORATION

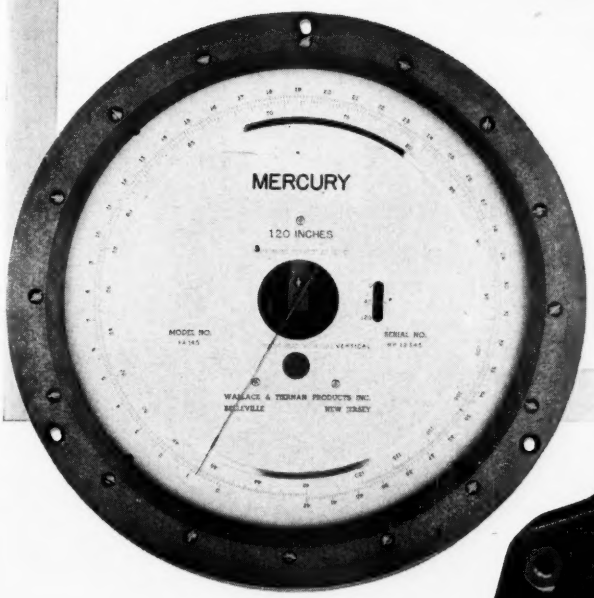
492 East Union Street • Pasadena 1, California

For more information circle **32** on inquiry card.

PRECISION PRESSURE MEASUREMENT

of Gauge Pressure, Vacuum or Differential Pressure

Precision Dial Manometer Type FA-145



Accuracy:
1 part in 1000 over full scale.
Sensitivity:
1 part in 10,000 in *all* ranges.
Ranges:
0 to 120 inches of water (min.)
0 to 250 inches of mercury (max.)
Other intermediate ranges available.
Scale Length:
45 inches.
Dial Diameter:
8½ inches.

Precision Low Pressure Gauge Type FA-141

Accuracy:
1 part in 300 over full scale.
Sensitivity:
1 part in 500 in *all* ranges.
Ranges:
0 to 10 inches of water (min.)
0 to 400 inches of water (max.)
Other intermediate ranges available.
Scale Length:
7 or 16 inches.
Dial Diameter:
2¾ or 6 inches.

WALLACE & TIERNAN
INCORPORATED
PRECISION INSTRUMENTS AND ELECTRICAL MECHANISMS
25 MAIN ST., BELLEVILLE 9, N. J.
In Canada: Wallace & Tiernan, Ltd., Toronto

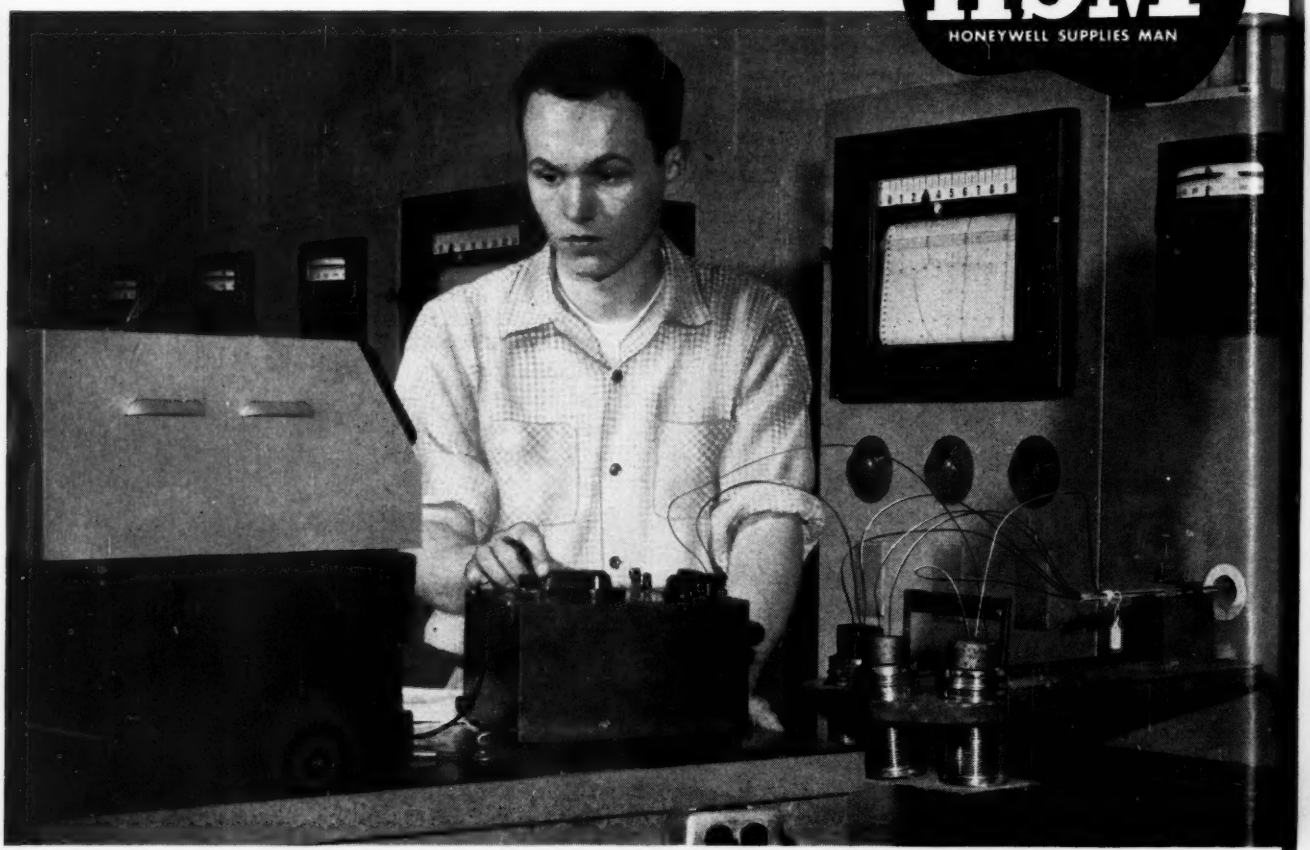
For additional data, write for Publication TP-30-A and TP-27-A

A-101

For more information circle 33 on inquiry card.

Lab-tested thermocouple wire *available through your*

HSM
HONEYWELL SUPPLIES MAN



CONNECT a thermocouple with only ± 1% accuracy to an instrument with accuracy of ± ¼% . . . and how closely can you measure? The answer is simple. Overall accuracy *can't* be any better than your thermocouple.

To guarantee you consistent accuracy in your temperature detecting elements, Honeywell maintains a fully equipped wire checking laboratory. Here every spool of thermocouple or extension wire is tested against standard wires that have been certified by the National Bureau of Standards. Checks are made at numerous points throughout the temperature range of the calibration in which the wire will be used. Every spool of wire meets rigid standards before it is accepted. Calibration figures are tagged on each spool.

The result of this laboratory control is that every order of Brown thermocouple or extension wire you receive can be counted on to deliver identical standards of high precision.

Ask your Honeywell Supplies Man to give you complete facts about Brown thermocouple and extension wires . . . and to tell you how the HSM Plan can bring you new convenience and economy in all your purchasing of pyrometer supplies. Call him today at your local Honeywell office . . . as near to you as your phone.

MINNEAPOLIS-HONEYWELL REGULATOR CO., *Industrial Division*, Wayne and Windrim Avenues, Philadelphia 44, Pa.—in Canada, Toronto 17, Ontario.

● **REFERENCE DATA:**
Write for Pyrometer Supplies Buyers' Guide No. 100-6.

H HONEYWELL

MINNEAPOLIS **Honeywell**
BROWN INSTRUMENTS
First in Controls

For more information circle **34** on inquiry card.

New Plants and Mergers

NORDEN-KETAY has acquired the assets, business, name and good will of *Gyromechanisms, Inc.*, Holesite, L. I., N. Y., announce *Morris F. Ketay* (Pres. of Norden-Ketay) and *Stokley Webster* (Pres. of Gyromechanisms).

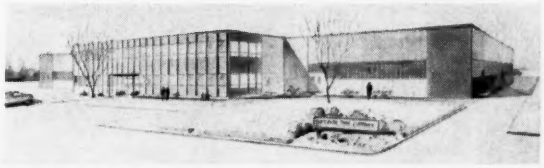
SWARTWOUT CO., Cleveland, Ohio., announces sale of a large portion of its power plant equipment division to Republic Flow Meters Co., Chicago, Ill.

SPINCO DIV., BECKMAN INSTRUMENTS, INC., Belmont, Calif., announces construction of a $500,000 re-

search and development center in Stanford Industrial Park for the advancement of medicine and diagnosis of disease.

GENERAL CONTROLS CO., Glendale, Calif., announces the acquisition of the precision potentiometer division of *Electro Circuits, Inc.*

ACTON LABORATORIES, INC., has acquired the entire *Instrument Div. of Technology Instrument Corp.*, announces *Lucius E. Packard*, President of Acton.



SUPERIOR TUBE CO. has begun construction of a half-million dollar plant and office building to replace the present plant at Wapakoneta, Ohio.

CONSOLIDATED ELECTRONICS INDUSTRIES CORP., New York, announces a net income for fiscal year 1955 as $861,988. C E I also announces the purchase of Price Electric Corp., manufacturers of relays.

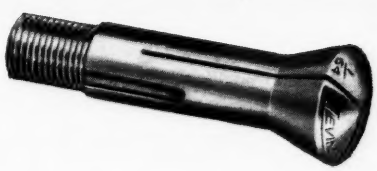
BALDWIN-LIMA-HAMILTON CORP. announces plans for construction of a new 102,000-sq-ft manufacturing plant at Waltham, Mass.

BLACK, SIVALLS & BRYSON announces formation of a new Eastern Sales Region for the division's operations,

SOLVE YOUR
MICRO-DRILLING
PROBLEMS

USE THE PERFECT COMBINATION
For Assured Accuracy

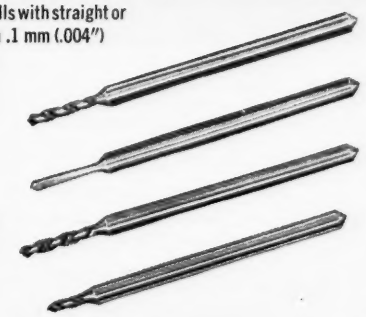
LEVIN® COLLETS



Super precision collets for jewelers type lathes. Ideal for holding micro-drills or other parts where concentricity is important. Available from stock in complete range of sizes from .004" (.1 mm) to 5/16" (8.0 mm).

SPHINX MICRO-DRILLS

High speed steel micro-drills with straight or spiral flutes in sizes from .1 mm (.004") to 3.0 mm (.1181"). Left hand micro-drills for use on Swiss type automatic screw machines. Short flute center drills. Send for Bulletin "Q" listing complete line of drills or Catalog M listing collets as well as full line of instrument lathes and accessories.



LOUIS LEVIN & SON, INC.—3610 S. BROADWAY—LOS ANGELES 7, CALIFORNIA

For more information circle **35** on inquiry card.

Berkeley news notes

NEW model 5846 MAGNETIC DUAL PRESET COUNTER

- *continuous-duty reliability!*
- *simplified installation, operation, maintenance!*

BRIEF SPECIFICATIONS
INPUT SENSITIVITY: 0.1 ma p-p into 10k load
OUTPUT SIGNAL: 5 amps (non-ind.)
ACCURACY: ABSOLUTE
PRICE (F.O.B. FACTORY): model 5846 (6 digit) $1,295.00.

Counts at rates to 10,000 per sec., produces electrical output signals at any two preset totals. Absolute accuracy. Operates from photocells, magnetic pickups, electrical contacts. Built-in DPDT output signal relay operates solenoids, solenoid valves, power relays, other control devices. First signal may be used to slow down operation preparatory to stop at final (second) count, etc. Has only two vacuum tubes (vs. 54 in electronic model), both used in low-level rf oscillator-power supply. Tamper-proof transparent cover, swing-out chassis construction.

Write today for Technical Bulletin; please address Dept. B-2

Berkeley
division of Beckman Instruments Inc.
2200 Wright Ave., Richmond 3, Calif.

80

For more information circle **36** on inquiry card.

PROTECT PRESSURE-SENSITIVE INSTRUMENTS . . . POSITIVELY

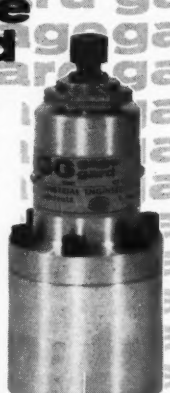
GG gage gard

Seals off gage or manometer connection at any pre-set pressure. Will repeat within 1% of scale. Will release 2% below cut-off point.

Models available with cutoffs from 20" water to 9000 psig. liquids and gases. Designed to withstand and hold closed against 10,000 psig.

Marine models available.

Write for Bulletin 541-G for full details and prices.



INDUSTRIAL ENGINEERING CORPORATION
525 E. Woodbine, Louisville, Ky.

For more information circle **37** on inquiry card.

PLANTS & MERGERS—CONTINUED

says *Chester A. Siver,* Vice Pres. and Gen. Mgr. of Controls Div., BS&B.

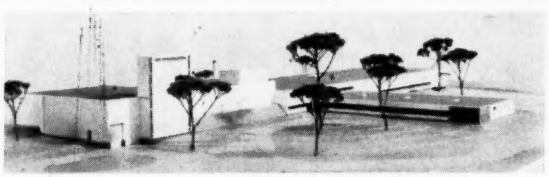
ELECTRODATA CORP. has dedicated the first of two new computer plant facilities in Pasadena's scenic Hastings Ranch.

T. J. COPE, INC., and **INSTROF CORP.** (its division) have moved from Phila. to Collegeville, Pa., announces *E. W. Baird,* Pres.

FREED TRANSFORMER CO., INC., Brooklyn, N. Y. has increased their engineering and research staff to meet requirements of commercial applications.

INTERNATIONAL BUSINESS MACHINES CORP. has been granted a license to manufacture printed circuits by the *Technograph process.*

HIGH VOLTAGE ENGINEERING, Cambridge, Mass., announces plans for a new building which will house the



world's largest radiation machine test facility. The Burlington, Mass., facility will cover 88,000 sq-ft.

ELECTRONICS CORPORATION OF AMERICA is selling pension and endowment funds to a group of insurance companies, announces *Arthur G. B. Metcalf,* Pres.

AMERICAN ELECTRONICS, INC., Marketing Div., has opened offices at 665 W. Washington Blvd., Los Angeles, Calif.

ELECTRONIC ENGINEERING CO., Los Angeles, Calif., announces an increase of 35% in net profit for the first 9 months of 1955 compared to 1954.

ATOMIC INSTRUMENT CO., Cambridge, Mass., announces 1955 shipments of over $1 million, a 15% gain over 1954.

VIKING INSTRUMENTS, INC., has plans to double the plant and production facilities at E. Haddam, Conn., announces *Alan Davis,* Pres.

BAIRD ASSOCIATES, INC., Cambridge, Mass., announces appointment of Advanced Instruments, Inc., Boston, as sales representatives for Baird's flame photometer.

LAMBDA ELECTRONICS CORP., Corona, N. Y., has opened new plant at 11-11 131 St., College Point, N. Y., announces *Lester Dubin,* Pres.

SPERRY RAND CORP. of New York announces plans for construction of an advanced flight research center and modern plant in Phoenix, Ariz.

NUCLEAR DEVELOPMENT CORP. of America will place a reactor critical facility in operation at its Nuclear Experimental Station in Dutchess County, N. Y., in 1956.

VARIAN NEWS *Dr. Russell H. Varian,* president of Varian Associates announces the company's entering in the high-energy radiation business with linear electron accelerators.

Thomas A. Edison Inc.'s

PERSONAL DEMONSTRATION

shows how you can

INCREASE PLANT PRODUCTION

Our representatives throughout the nation are ready to demonstrate *a complete* Omniguard system right at your plant or office.

Takes Only a Few Minutes to Prove Simple Omniguard System Protects Bearings and Processes; Cuts Down Time; Increases Equipment Life

Just take a few minutes to prove to yourself how Omniguard can make it possible for you to operate your equipment at peak production rates without fear of breakdowns . . . how this simple temperature detection system gives you ample opportunity to prevent bearing failures or to keep process temperatures within limits.

RECORDS REVEAL FAILURES COSTLY

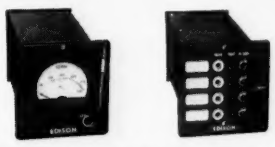
Many operators—after a record check—are astonished to find how much bearing breakdowns have been costing them in maintenance and lost production. They see that the cost is often many times the expense of installing Omniguard.

COMPLETE 4-POINT SYSTEM FOR LESS THAN $500

Consider the thousands of dollars involved in equipment and production output. Contrast this with the fact that one Omniguard unit costs less than $500. And because of its simplicity, installation costs are also low.

SIMPLE, DEPENDABLE

Omniguard has no electronic or moving parts. It is the most dependable system available today. Modular in design, each unit gives you four-point detection. You can add as many as you need . . . as you need them.



The modular indicator and monitor, with their mounting brackets, and the resistance temperature detectors, are all you need for a continuous operating analysis of remote process or bearing temperatures.

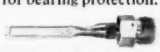
Resistance Temperature Detectors

These are just four of the many different types of temperature detectors produced for varied applications of the Omniguard system.

The 242P for high temperatures (to 1300°F.)

The 166NC with pre-loaded sensitive tip specially designed for bearing protection.

The 230N for general purpose industrial use (stem-sensitive).



The 235N90-35 for fast response in corrosive service.

A Partial List of Present Users

American Blower Corp.
City of Chicago
Combustion Engineering, Inc.
DeLaval Steam Turbine Co.
Eastman Kodak Co.
Esso Standard Oil Co.
Florida Power & Light Co.
General Electric Co.
Hercules Chemical Co., Inc.
I-T-E Circuit Breaker Co.
North American Aviation, Inc.
Public Service Electric & Gas Co.
Republic Steel Corporation
Sun Oil Company
Union Carbide & Carbon Corp.
Westinghouse Corp.

Thomas A Edison

A GREAT NAME CONTINUES GREAT NEW ACHIEVEMENTS

Thomas A. Edison

INCORPORATED

INSTRUMENT DIVISION • 34 LAKESIDE AVENUE • WEST ORANGE, NEW JERSEY

To get your free demonstration, just fill out the coupon below.

Please have representative call for appointment at no obligation to me_____

Please send detailed information_____

Name_____

Firm_____

Address_____

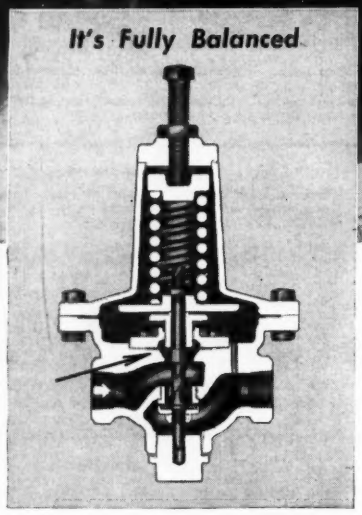
_____

Position_____

For more information circle 38 on inquiry card.

Here is the new LESLIE "HI-FLO" Water Reducing Valve with 50% more capacity

It's Fully Balanced



Unique construction of "Hi-Flo" Reducing Valve. Note the small lower diaphragm that provides fully balanced, floating action.

HERE IS THE ALL NEW Leslie Reducing Valve with *capacity-regulation* features that have never been offered before. Here is a regulator with 50 - 100% greater capacity by actual test.*

Here's the unbeatable combination of design features:

"HI-FLO" — Large bowl construction; long stroke diaphragm gives full flow of water and other non-corrosive liquids.

FULLY BALANCED — The main valve, fully balanced by lower diaphragm, virtually floats to provide smooth, friction-free, throttling action.

DROP-TIGHT SHUTOFF — Resilient seating disc provides tight closure under all conditions.

TROUBLE-FREE DESIGN — Chatter and hammer eliminated; no piston cups or seals to clog or change. Corrosion resistant trim with renewable interchangeable fit.

Ask your Leslie Engineer to show you how the exclusive Leslie "Hi-Flo" valve can be used to your advantage in water reducing stations, fuel oil pressure control, process lines, etc. He's in your classified directory under "Valves" or "Regulators".

Write today for Bulletin 553 for graphic performance comparison and complete capacity data.

TRADE LESLIE MARK

REGULATORS AND CONTROLLERS

LESLIE CO., 299 GRANT AVENUE, LYNDHURST, NEW JERSEY

CONTROLLED QUALITY MEANS QUALITY CONTROLS

For more information circle **39** on inquiry card.

This Bailey Armortube* Cable can save you time and money

With this new material especially designed for pneumatic connecting lines you can make better instrument and control installations in less time and at less cost. Here's why:

Simple — Standard ARMORTUBE* cable is stocked in three convenient sizes: bundles of four, eight, or twelve ¼ inch O.D. aluminum alloy or copper tubes. Other sizes are available on special order. It's a ready-made, fully protected piping material for transmitting pneumatic signals between measuring units, instruments, and control units.

Safe — The flexible metallic covering guards against every hazard, internal or external. Patented rope-like arrangement of tubes eliminates danger of collapse at sharp bends—and damage from external blows or vibration is minimized by protective outer covering.

Compact — All necessary lines can be snaked through tight quarters or around corners with a minimum of connections. No need for unsightly, bulky channels, racks or other special mountings.

Economical — Installation is fast. 100 foot coils and 500 foot reels permit long unbroken runs. Colored tracer simplifies connections at terminals. Slightly higher first cost is quickly amortized by savings in materials, and installation time. For further information and specifications ask for Bulletin and Price List G91-9.

P-30

* Registered Trade Mark

BAILEY METERS

BAILEY METER COMPANY

1041 IVANHOE ROAD • CLEVELAND 10, OHIO

INSTRUMENTS AND CONTROLS

For more information circle **40** on inquiry card.

A New High in Operating Convenience

Pushbutton selection of 12 chart speeds —1/16 to 160 inches per second

Timing line intervals automatically controlled by chart speed setting

Galvanometer trace zero adjustment at front panel

Oscillograph can be controlled, completely from a remote location

The S-25 Oscillograph

The S-25 is a new laboratory oscillograph of advanced design. It has many unique features that make it simple and unusually convenient to operate in a wide variety of recording applications. When next you consider the purchase of an oscillograph, please compare the unequaled specifications of the Hathaway S-25 with those of any other oscillograph.

SPECIFICATIONS

Channels: To 36

Chart Size: 8 inches x 300 feet

Chart Speeds: 1/16 to 160 inches per second in 12 steps

Chart Speed Change: Electric transmission; speed selected by panel pushbuttons—while oscillograph is in operation, if desired

Timing Lines: At 1, 1/10, 1/100 or 1/1000 second intervals; interval automatically controlled by chart speed or manually selected, if desired

Galvanometer Zero Adjustment: Knobs are conveniently located at oscillograph front panel for galvanometer trace zero adjustment

Reserve Recording Lamps: Lamps replaced automatically upon burnout

Viewing and Scanning Screen: Variable speed polygon mirror for calibration or monitoring of repetitive waveforms

Record Numbering: Record number is printed photographically along chart edge at 2-foot intervals

Writing Rate: Traces are individually adjustable to desired rate

Trace Density: Automatically controlled by chart speed

Record Length Control: Record length may be preselected, in one-foot increments, up to 50 feet

Chart Travel Indicator: Panel lamp gives positive indication that chart is being driven properly

Chart Supply Indicator: Indicator on control panel shows number of feet of unexposed chart

Remote Control: Oscillograph can be controlled, from distances up to 100 feet, by means of its removable control panel and cable

Ready Indicator: Panel lamp will not light if all operating controls have not been properly set

Case: Lightweight aluminum

For complete information, write for Bulletin 2-K-1-H

Hathaway
INSTRUMENT COMPANY

SUBSIDIARY OF
Hamilton
WATCH COMPANY

1315 SOUTH CLARKSON • DENVER, COLORADO

For more information circle 41 on inquiry card.

MINNEAPOLIS-HONEYWELL REGULATOR CO., INDUSTRIAL DIV. announces addition of 21 new sales engineers to the field sales force. The new sales engineers, all graduates of the division's training school's 20th anniversary class, include: *William Bater* and *Robert W. O'Reilly* (Phila.); *David B. Beasley* (Toronto); *Walter E. Biewer* and *Robert E. Day* (Los Angeles); *Robert J. Byers* (Milwaukee); *A. P. Ciprari* (New York); *Alan L. Colter* (Buffalo); *John L. Dyer* (Cincinnati); *Merton H. Fischer* (Minneapolis); *Michael N. Francher* (Syracuse); *Eugene D. Haugen* (Seattle); *Charles C. Hulsey* (Columbia); *Charles B. MacRae* (Houston); *Robert J. Owen* (Cleveland); *John B. Prouty* (Columbus); *Harvey F. Renee* (Indianapolis); *Bertram R. Robinson* (Union); *Russell W. Skinner* (Pittsburgh); *Jack D. Stickley* (Oklahoma City); and *Richard E. Swenson* (Twin City).

FOXBORO CO., Foxboro, Mass., announces appointment of *E. W. Prendergast* as regional manager of the Southeast territory, and the following appointments of industrial engineers: *R. F. Sutton* transferred from the Pittsburgh office to Pensacola, Fla.; *F. J. Stevens, Jr.* at the Lakeland, Fla., branch; *H. C. Craig* as branch manager in Jacksonville; *L. C. Estes*, Atlanta branch; *W. H. Rhyne, T. A. Jones* and *M. N. Walker* to the Chattanooga, Charlotte and Knoxville offices; *G. W. Reed, Jr.*, has been named manager of the New Orleans office; and *J. K. Younkins*, manager at Charleston, W. Va.

BALDWIN-LIMA-HAMILTON CORP. announces appointment of *Alfred N. Rogers* as chief engineer of its Nuclear Engineering Dept.

People IN THE NEWS

TAYLOR INSTRUMENT COMPANIES, Rochester, N. Y., announce election of *Frank S. Ward* to the Board of Directors and a member of the executive committee; *Marc E. Porter* as assistant treasurer; and *Karl H. Hubbard* as technical director.

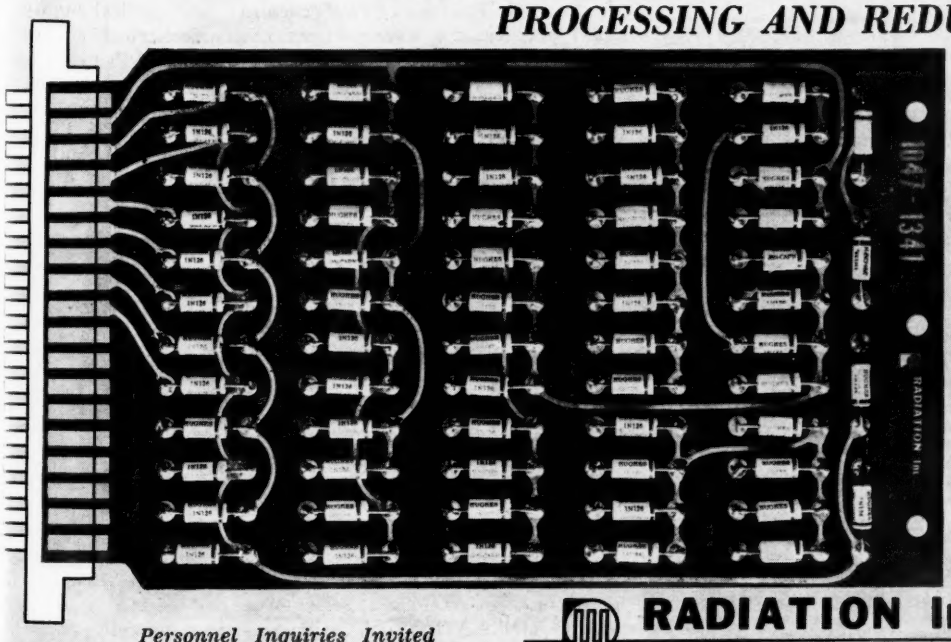
Frank S. Ward
Taylor Inst. Cos.

Stokley Webster
Norden-Ketay

NORDEN-KETAY announces appointment of *Stokley Webster* as general manager of Gyromechanisms Div., recently acquired.

SERVO CORP. OF AMERICA, New Hyde Park, L. I., N. Y., announces appointment of *Frank G. Wiley* as sales

Advanced DIGITAL TELEMETRY SYSTEM
FOR COMPLETE DATA COLLECTION, PROCESSING AND REDUCTION



Illustrated is a "4 x 16" Matrix, employing 64 Germanium Diodes for converting Binary Digital data to corresponding analog levels in Radiation, Inc.'s "Quick-Look" Recording System.

The "Quick-Look" System provides the test engineer with an instantaneous visual record, from which he may select pertinent data for subsequent reduction by means of a high speed Digital Computer.

The "Quick-Look" Recording System comprises just one small portion of Radiation Inc.'s advanced high speed, high capacity Digital Telemetry system.

Personnel Inquiries Invited

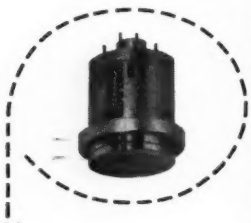
RADIATION Inc. Melbourne, Fla. Orlando, Fla.
Electronics • Avionics • Instrumentation

For more information circle **42** on inquiry card.

If it's pressure measurement

Think first of CEC PRESSURE PICKUPS

Range . . . adaptability . . . compactness . . . accuracy. Get them all with CEC's famous 4-300 series of pressure pickups, plus an important extra: *dependability*. Accurate enough for the most critical laboratory work, they're also rugged enough for rocket tests. *All* characteristics of every unit are measured, and a signed calibration certificate is sent with *every* unit.



accuracy . . . as low as .75% linearity deviation on standard units. Lower values of linearity can be obtained on special order.

ranges . . . gage, absolute and differential units . . . ± 1 to + 5000 psi full-scale.

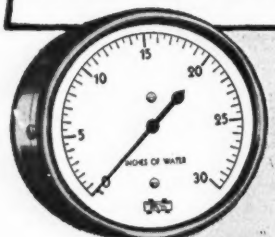
size . . . bodies as small as ½" diameter.

mounting . . . flush diaphragms, standard pipe threads, or AN fittings.

This is the actual size of a CEC Pressure Pickup. For complete information about them, write today for Bulletin CEC 1552-X39.

Consolidated Electrodynamics
CORPORATION
Formerly Consolidated Engineering Corporation
ELECTRONIC INSTRUMENTS FOR MEASUREMENT AND CONTROL
300 North Sierra Madre Villa, Pasadena, California
For more information circle **43** on inquiry card.

MARSHALLTOWN



DIAPHRAGM GAUGE

For Accurate Pressure Measurement in Ounces or Inches of Water

Available in standard dials (reading in inches of water) 0-15" —0-30" —0-60" —0-100" —0-160" . . . also in ounce graduated dials from 15 ounces to 5 pounds. 2½", 3½" and 4½" dial sizes mounted in black enameled steel case.

Marshalltown Figure 83 is an extremely sensitive gauge that uses a carefully seasoned bronze diaphragm to accurately measure very low pressures. It is used extensively on many types of natural gas installations for checking low pressures.

Write for details and price. LOOK TO MARSHALLTOWN FOR ONE OF THE MOST COMPLETE LINES OF INDICATING PRESSURE GAUGES MADE!

MARSHALLTOWN MANUFACTURING CO.
MARSHALLTOWN 3, IOWA
For more information circle **44** on inquiry card.

PEOPLE—CONTINUED

manager and *Warren Schoonmaker* as sales promotion manager.

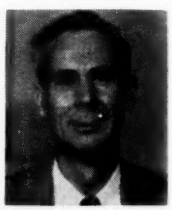
GENERAL PRECISION LAB., INC., announces the following organizational changes: *N. M. Marshall* will direct sales of television equipment; *J. W. Belcher* has been named manager of Application Engineering Dept.; and *S. T. Pardee* has been named publicity manager.

VEEDER-ROOT, INC. announces appointment of *Rex M. Bathurst* as plant manager of the branch plant in Altoona, Pa.

INDIANA STEEL PRODUCTS CO., Valparaiso, Ind., announces appointment of *Herbert R. Toler* as a Research Engr.

NEELY ENTERPRISES has elected *Robert L. Morgan* vice president in charge of engineering at Neely Enterprises. Succeeding him as sales manager is *Robert H. Brunner*. *Cal Worley* has joined the San Francisco office as Field Engineer, and *Ken O'Neal* has joined the San Diego office.

R. H. Brunner
Neely Enterprises



Milton A. Chafee
Fairchild Camera

FAIRCHILD CAMERA AND INSTRUMENT CORP. announces appointment of *Milton A. Chafee* as Director of Electronics and Systems Research.

LIQUIDOMETER CORP., Long Island City, announces appointment of *Louis M. Campani* as chief administrative engineer; *Julius V. DiFranco* as chief electrical engineer; *P. Richard Rosenbert* as chief mechanical engineer; *Edgar Astrove* as administrative assistant; and *Edward Chowske* as supervisor of the Industrial Engineering Group.

ELECTRONIC ENGINEERING CO. OF CALIF. announces appointment of *Donald R. Proctor* as assistant engineering manager in the Los Angeles Div.

D. R. Proctor
Electronic Engrg.

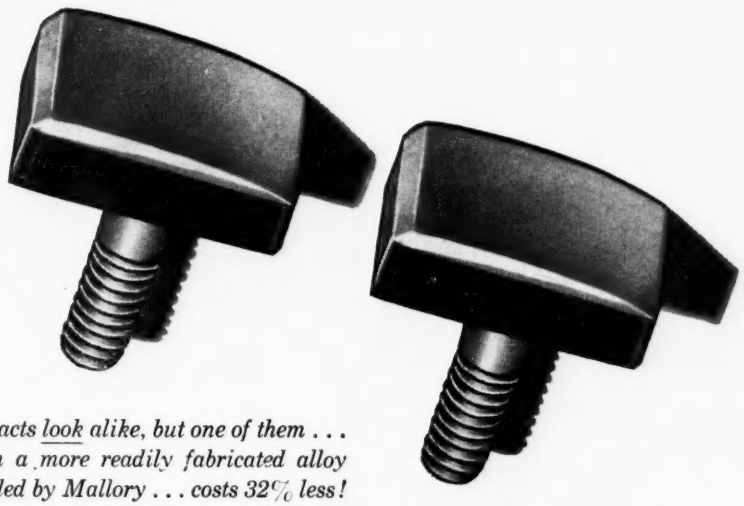
R. B. Hubbard
ACF Industries

ERCO DIV. OF ACF INDUSTRIES announces appointment of *Richard B. Hubbard* as president of the ERCO Div.

J. B. REA CO. announces appointment of *W. V. Neisius* as director of the Computing Applications Dept.

LINK AVIATION, announces four executive appointments: *George Friedl, Jr.*, as director of advanced planning; *William W. Wood, Jr.*, succeeds Friedl as head of

MALLORY



These contacts look alike, but one of them . . . made from a more readily fabricated alloy recommended by Mallory . . . costs 32% less!

Mallory Engineered Materials Selection Can Cut Your Contact Costs

Mallory Contact Engineering Offers Five Ways To Improve Economy

1. **The most effective contact material** from the extensive line developed by Mallory. More economical alloys often can satisfy *actual* service conditions.
2. **The most economical contact design** . . . for your purchasing, production and product needs.
3. **The most economical backing material** . . . from a group of Mallory alloys developed for this use.
4. **The most economical backing member design** . . . in relation to contact and product design requirements.
5. **The most economical method of assembly** of contact and backing member.

By coordinating *all* these important elements of contact design, Mallory can help you put into effect a long-range plan for cutting contact cost and assuring peak performance.

CHOOSING the contact material that exactly matches your product requirements can often reduce over-all contact costs. For example, designers of a circuit breaker selected one of the Mallory Elkonite® materials for the contacts. This is a superior material for heavy-duty service, with high resistance to sticking and arc erosion.

Mallory engineers examined the product requirements . . . and recommended a change in materials. They found another ELKONITE, a higher silver content material, would give excellent performance on this medium-duty application. And because this material involved fewer manufacturing operations, the contacts could be made at lower cost. The customer's savings amounted to $10.16 per thousand . . . a total of over $8,000!

Mallory engineers are especially well qualified to help you get the best economy and performance in your contacts. They have a uniquely broad range of Mallory contact alloys from which to choose. And their extensive application experience is valuable in coordinating *all* phases of contact, backing member and assembly design to assure you of top value for your contact dollar. Write or call Mallory for a consultation on your particular application.

Expect more . . . get more from

P. R. MALLORY & CO. Inc.

MALLORY

P. R. MALLORY & CO., Inc., INDIANAPOLIS 6, INDIANA

Serving Industry with These Products:

Electromechanical—Resistors • Switches • Television Tuners • Vibrators
Electrochemical — Capacitors • Rectifiers • Mercury Batteries
Metallurgical—Contacts • Special Metals and Ceramics • Welding Materials

For more information circle **45** on inquiry card.

PEOPLE—CONTINUED

manufacturing; *John M. Hunt* as manager of engineering division; and *Monson H. Hayes, Jr.*, replaces Hunt as director of research and development.

CANNON ELECTRIC CO., Los Angeles, announces appointment of *Fred Stricker* as manager of the Canseal Dept.

ILLINOIS INSTITUTE OF TECHNOLOGY announces election of *Harald C. Mueller* as alumni representative on the board of trustees.

H. C. Mueller
Illinois Institute

H. J. Mossien
Bausch & Lomb

BAUSCH & LOMB OPTICAL CO., Rochester, N. Y., announces creation of a laboratory and inspection products sales department with *Herbert J. Mossien* as manager and *Robert J. Sparling* as assistant manager.

BERKELEY DIV., BECKMAN INSTRUMENTS, INC., announces addition of *David C. Kalbfell* to its consulting staff.

DAYSTROM, INC., president *Thomas Roy Jones*, announces that *Robert LeBaron* will assist in the expansion of Daystrom activities in the atomic energy field.

INDUSTRIAL INSTRUMENT CORP. announces appointment of *J. G. Parrott* as production manager.

G. J. Parrott
Ind. Inst. Corp.

Robert L. Sink
CEC

CONSOLIDATED ELECTRODYNAMICS CORP. announces establishment of an Advanced Electronic Data Laboratory. Named to head the laboratory, which will be located in Pasadena, was *Robert L. Sink*, former assistant director of engineering for CEC.

WATERS MFG., INC. of Wayland, Mass., announces appointment of *James W. Sauber* as chief instrument engineer.

BECKMAN DIV., BECKMAN INSTRUMENTS, INC. announces appointment of *Edwin A. Houser* to the Application Engineering staff.

BRUSH ELECTRONICS DIV., CLEVITE CORP. announces appointment of *Edward F. Crafts* as advertising and sales promotion manager.

COMPUTER-MEASUREMENTS CORP., North Hollywood, Calif. announces appointment of *R. E. Lovejoy* as Director of Research for the counting and computing instrument division.

Now you can
solder as easy as you write!
—with
HEXACON
INSTRUMENT SOLDERING IRONS
—for fast soldering and long life on constant duty

Because of new efficient design, these tiny tips out-perform irons with larger tips and higher wattages. HEXACON offers a new standard in soldering iron efficiency for every conceivable need in the soldering of miniature assemblies.

Send for new circular No. 127 giving more details and comparative competitive performance data.

SUPER-PENCIL IRONS*
No. 25S 25w. 1/8" tip $5.50
No. 26S 30w. 3/16" tip $5.50

BANTAMWEIGHT HATCHET IRONS*
No. 25H 25w. 1/8" tip $6.00
No. 26H 30w. 3/16" tip $6.00

PIN-POINT IRONS*
No. P-25A 25w. 1/8" tip $5.50
No. P-26 30w. 3/16" tip $5.50

*Also available in higher wattages

INDUSTRY'S No 1
HEXACON
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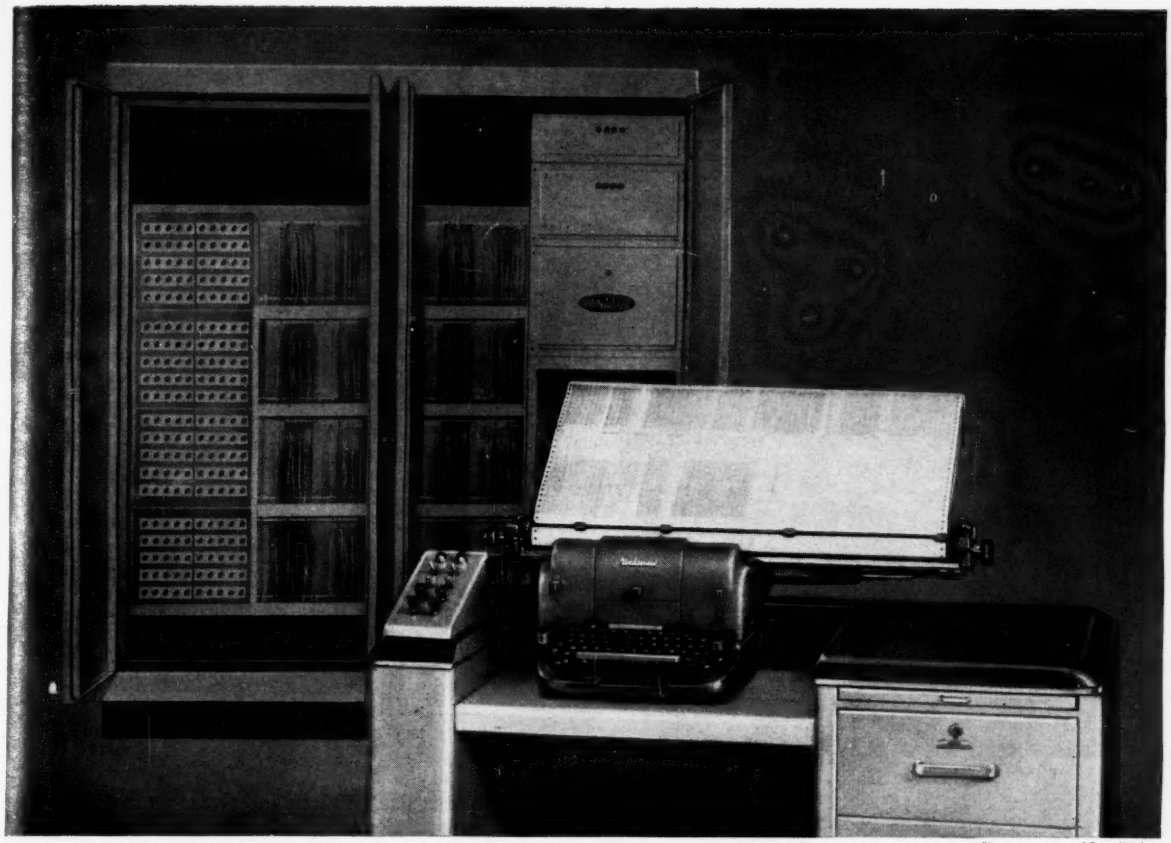

Photo courtesy of Panellit, Inc.

New Underwood Servotyper records data automatically

Now, for the first time, you can have automatic data recording equipment at a reasonable price. Underwood's new Servotyper offers automatic recording of digitized and alphabetic data, plus all the advantages of the well-known rugged durability of the Underwood Electric Typewriter.

The Underwood Servotyper is a slave electric typewriter. The keys are operated by solenoids which are triggered by electrical signals, at speeds up to 11 characters per second. A great variety of standard devices—quantizers, punched tape readers, digital converters, punched card readers, diode matrices, transducers with digital outputs—are already available for translating your data into electric signals. These signals are simply and directly used as inputs for automatic operation of the Underwood Servotyper.

The Underwood Servotyper can be applied to many data logging and telemetering problems—test and research results, process variables, payroll facts, inventory details, maintenance data, meteorological data, etc.—anywhere information is secured by electrical instruments. For complete information and prices of the Underwood Servotypers, call your Underwood Office, or write Underwood Corporation, One Park Avenue, New York 16, New York.

These features are standard equipment on the new Underwood Servotyper:

- Solenoid operation of all keys, space bar, shift key, back space, carriage return, tabulation and red ribbon.
- Standard keyboards.
- Speed of operation to 11 characters per second.
- Self governing feedback switch provides true servo operation; supplies proper pulse to govern associated equipment, so that it operates at maximum typing speed.

UNDERWOOD CORPORATION

One Park Avenue, New York 16, N. Y.

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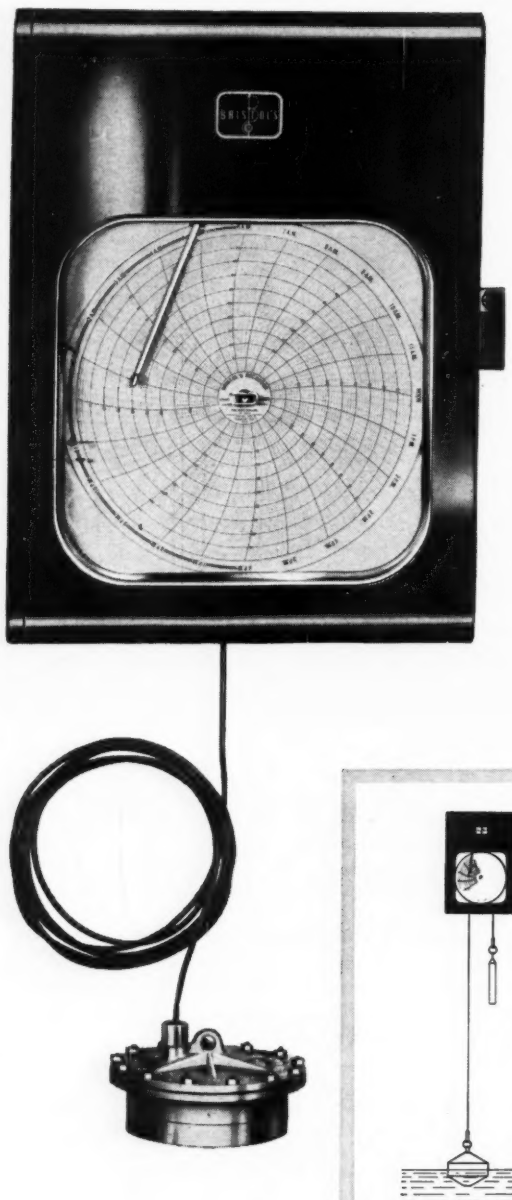
WHAT'S NEWS AT BRISTOL . . .

Bristol Liquid Level Gauges keep tabs on unruly liquids



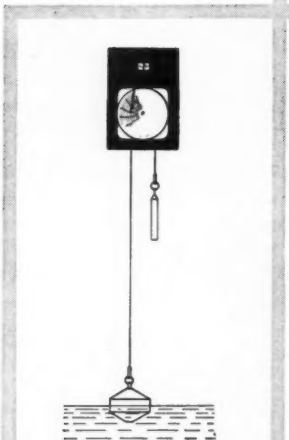
Measuring or controlling the levels of liquids can be quite a problem at times.

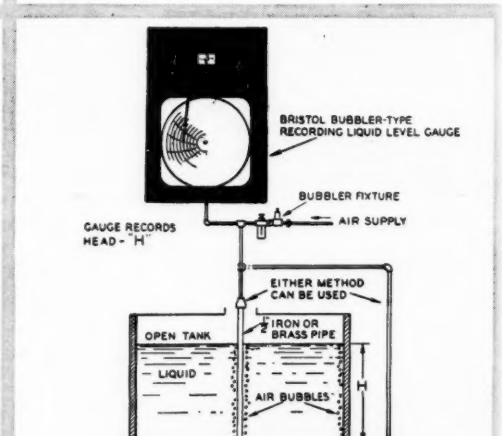
Especially if the liquid is flowing, turbulent, corrosive, covered with ice, carrying solid matter, or contained in a closed vessel where its surface is under static pressure.

Solving any of these problems is easy with a Bristol Liquid Level Gauge. These widely-used precision instruments indicate, record, and automatically control the level of almost any liquid without difficulty. They'll read in feet, inches, fathoms – any unit of measurement you desire.

What's more, there's a standard Bristol Liquid Level Gauge for practically every application – including Float, Pressure Bulb, Pressure, and Bubbler type Gauges and Controllers. Our field engineers will gladly study your problem and make recommendations.

Write for complete information on the instrument that will fully meet your requirements. The Bristol Company, 113 Bristol Road, Waterbury 20, Conn. 5.15





PRESSURE-TYPE GAUGES for measurement and control of levels in open vessels can be adapted to any type of mounting.

FLOAT-TYPE GAUGES are designed to measure levels of large bodies of water such as supply reservoirs or lakes.

BUBBLER-TYPE GAUGES measure levels of corrosive and solid-carrying liquids like those in pulp mills or sewage plants.

BRISTOL *POINTS THE WAY IN HUMAN-ENGINEERED INSTRUMENTATION*

TRADE MARK BRISTOL'S REG U.S. PAT OFFICE

AUTOMATIC CONTROLLING, RECORDING AND TELEMETERING INSTRUMENTS

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SIGNIFICANCE

D. J. Pompeo—known affectionately and well throughout the process industries as "Pomp"—has been at the forefront of several of the most basic instrumental advances of the last two decades. Although our field has been characterized lately by a barrage (if not a smokescreen) of "revolutionary" disclosures about feedback, manless plants, etc., etc., the facts are that the key developments in automatic process control within the last two decades have been (1) the development of on-stream analytical instruments to supplement environmental instruments and (2) the development of techniques for obtaining dynamic characteristics of unit processes by frequency response and other methods. The closing of loops between the material input and the product output of processing plants will depend on the developments in these fields, which Pomp has been guiding for more than two decades.

The following biography shows the evolutionary development of the field of process instrumentation through its various stages—it does *not* do justice to Pomp's many contributions to this development. His latest honor has been his selection by his colleagues in the North California Section, ISA, as "an outstanding instrument engineer," making him a candidate for The Outstanding Engineer Award to be presented on February 23, 1956, during the Bay Area Engineers' Week activities.

We invite you to meet Pomp, and we wish to acknowledge publicly his outstanding contributions to the many key instrumental advances described in the following biography.

* * *

Clarence Glassbrook is of that breed of key men who nominally are in charge of the "Instrumentation" of a research organization—which in practice means designing, maintaining, consulting, and making practical that research which depends on instrumentation. Such men have become key elements in the research organization, performing an essential impedance-matching function between the researcher and his instrumental tools. You have already met Charles Lucks of Battelle in these columns; and you will meet similar key men from other research laboratories. This month we invite you to meet Clarence Glassbrook of Stanford Research Institute; we are pleased to acknowledge his contributions to the field of instrumentation, and his key position within it.

INSTRUMENTS and AUTOMATION

Biographies of significance

D. J. POMPEO

D. J. Pompeo was born in Jersey City, New Jersey on April 26, 1901, and after graduation from the Jersey City High School, gained practical experience at the Engineering Department of Cooper Hewitt Electric Company in Hoboken, New Jersey, where he learned instrumental techniques as well as the art of working in glass and quartz. He left the east at the suggestion of Drs. R. A. Millikan and George E. Hale to further his education at the California Institute of Technology in Pasadena, California, and to work part time at the Mt. Wilson Laboratory in Pasadena. "Pomp," as he is known to friends and associates, graduated in 1926 with a B.S. degree in Physics and Engineering. The next two years were occupied in freelancing; i.e., fabricating scientific glass apparatus, and one year of coaching the freshman baseball team.

In October of 1928 he accepted a position at the Shell Development Company, which was starting operations in Emeryville, California, to organize a glassblowing and instrument development department. Much had to be done to properly equip a chemical laboratory with the tools for conducting research. This required purchase of standard glass apparatus and instruments, and fabrication of specialized equipment such as distillation columns, diffusion pumps and McLeod gages.

With the growth of the laboratory the glassblowing and instrument activities gradually separated so that now there are two separate groups. The glassblowing section consists of 9 glassblowers and a foreman, with a working area of 1800 square feet (about a 9-fold increase in area from the start of operations). Instrumentation has grown to a total staff of 42 people, with D. J. Pompeo as department head, together with an assistant department head (P. R. Hoyt) and three supervisors (W. B. Milligan, C. J. Penther, and V. N. Smith). Space requirements have increased from about 400 square feet (in 1928) to some 6700 square feet (in 1955).

200 Watt A.C. Low Inertia Servo Motor

Short life, overheating and unsatisfactory response—these are your only rewards when you use an underrated Servo Motor on a job demanding a bigger rating. If *faster* response and *more* output are what you need to solve existing problems in your Servo Motor applications—it's time to investigate DIEHL Servo Motors.

The DIEHL ¼ HP (200 watt output) Servo Motor has proved especially successful in overcoming problems in a wide range of applications. Capable of continuously delivering rated maximum output without exceeding rated temperature rise when excited at rated voltage and frequency from a suitable polyphase power source, these open-type 60 and 400 cycle low inertia Servo Motors feature an integrally-mounted auxiliary motor-blower. A look at the other specifications—and at your Servo Motor requirements—may reveal many practical uses for these *higher powered* DIEHL Servo Motors in your operations. *Write today for complete information on Servo Motors rated up to 1 HP (750 watt output).* IA256

SPECIFICATIONS

DIEHL Number	ZP105-2212-1	ZP105-2217-1
Output (watts)	200	200
Frequency (cycles)	60	400
Poles	2	6
Reference Phase (volts)	115	115
Control Phase (volts)	115	115
Reference Phase (watts)	380	410
Control Phase (watts)	380	410
Control Phase Impedance (Ohms)	30	19
Locked Torque (Oz. In.)	190	105
Moment of Inertia (Oz. In.²)	6.60	6.60
Theoretical Acceleration (Rad/sec.²)	11100	6140
Weight	14 lbs. 8 oz.	14 lbs. 8 oz.

Booth 3
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BIOGRAPHIES—Continued

The latter includes office space and about 1400 square feet for the instrument model shop.

Expansion of instrumental activities took place in three stages. Efforts at first were directed towards development, design and construction of laboratory instruments and apparatus. A number of these are now being used in refinery and chemical plant control laboratories. Some 40 pieces of apparatus have been licensed for manufacture and have been made available to industry. A few of these are: apparatus for surface area measurement, cryoscopic molecular weight, quartz tube sulfur, vacuum manostat, bubble plate columns, kinematic viscosity bath, semi-automatic ASTM distillation and oil oxidation equipment. The latest development is a unitized gas-liquid partition chromatographic apparatus of which 7 have been constructed and are now operating in various Shell plants.

The second stage got underway in the latter thirties with development of the continuous recording analyzers based on physical principles of measurement. It had been recognized that in order to obtain better control of processes and product quality, instruments other than environmental (temperature, pressure and flow) are needed. Work in this field led to development and application in processing plants of continuous recording instruments for water in organic material by dielectric measurement, gas and liquid analysis by infrared and ultraviolet absorption and by beta ray absorption, and petroleum tests such as viscosity, color, initial boiling point, and Reid vapor pressure.

The third stage in the growth of the department was the consolidation of a group handling the testing and evaluation of commercial types of plant control instruments. The function of this group is summarized by Messrs. Bremer and Stanton in the March 1952 issue of *Instruments*. Briefly the objectives are as follows: (a) to obtain data on static and dynamic characteristics of new instruments commercially manufactured; (b) to design and construct working models of control instruments as distinguished from the analytical type; and (c) to obtain field data of dynamic characteristics in control loops of processing units by frequency response and other methods. From theoretical and practical studies, data so obtained have led to improvement in over-all system control. For these tests in the field, a new truck is being made available, pro-

vided with many conveniences for efficient procurement of data.

Results obtained from the instrument evaluations, as well as the progress of Shell's own instrument developments, are reported to the engineers in Shell to familiarize them with the latest instruments and assist them in applying these to existing or new installations. As a part of this service, a one-year training program for refinery instrument engineers has been underway for the past few years on all phases of the Shell Development instrument activities.

Pomp tells us that *I&A* has been an important factor in this educational picture. He says, "I have read *Instruments and Automation* for at least twenty years and have subscribed for about fifteen. In addition to the technical articles and new instruments, I feel that your *Instrument Index* published each year has been and will continue to be of great importance in the coming years."

Pomp has authored or co-authored eleven papers on instruments and apparatus. He is married and lives in Oakland, Calif.

CLARENCE I. GLASSBROOK

Clarence I. Glassbrook's own appraisal of himself is that of a chemist gone astray. "Should have been a mechanical engineer, I suppose," he says. "I got into the instrument side of chemical production and industrial research because I have always liked to make things with my hands and because on every chemical process I ever had anything to do with we needed to know something more about it than we could get from the instruments we had."

Cal, as all his associates know him, is a native of Portland, Oregon, but went to Stanford for his university training, obtaining a B.S. in physical chemistry in 1935 to which he added an M.S. the next year. Then he went east—to East Providence, R. I.—to become assistant superintendent of the oil refinery and asphalt-emulsion plant of the American Bitumuls Co., a subsidiary of Standard Oil of Calif. After four years—in 1941—he joined Westvaco Chlorine Products Corp. at Newark, Calif. This plant is concerned with producing magnesia and other products from seawater. In 1944 and until 1949, Cal served as research chemist for Socony Vacuum Oil Company at Paulsboro, N. J.

Following this industrial experience he came to Stanford Research Institute, Menlo Park, Calif., where he has been and still is in charge of instrumentation. Here he concentrates on the research and development of new analytical instruments for automatic continuous process control. Several instruments of his design and construction are in use at the Institute. Typical are a sodium analyzer for lead-sodium alloy, a fluoride recorder for hydrogen fluoride in the atmosphere, and an analyzer for organic chlorides. Nine patents have been granted on his developments. He spends much of his time rebuilding commercial research-

type instruments to suit particular project needs.

Instrument maintenance at SRI has been delegated to the persons using the instruments, insofar as possible, because instrument development activities and instrumentation for new projects require the greater part of his time.

When asked to describe his present facilities, Cal said: "According to Webster, a pen-knife can be classed as an instrument, however in my book an instrument is a complex gadget requiring an occasional application of tender loving care. The following list of instruments at SRI will give you an idea:

Emission Spectrograph—Electron Microscope—Two Infrared Spectrographs—Mass Spectrograph—X-ray diffraction and fluorescence unit—Fluoride Recorder—3 spectrophotometers—Oscillometer—Electrophoresis unit—Two Automatic Titrators—Polarograph—Seven Recording Potentiometers—Four Indicating Potentiometers—Data Reduction Machine (with unpredictable analog to digital converter)—Various pH meters—Various Geiger counters, scalers, etc. —Several home-made temperature controllers (these are good to ±2 microvolts of thermocouple EMF)—Light scattering device—Various gadgets we make up for specific applications such as fraction splitters, explosive decompression bomb, Toepler pump automatic controller, etc. —Various microscopes, refractometers and other optical devices.

"In reading the above, it occurs to me that my definition of an instrument could also be applied to a wife, with the difference however, that the behavior of the instrument is usually predictable."

Cal reports that vapor phase chromatography is by far the most interesting of the new analytical tools; however, the use of X-ray fluorescence could lead to rather startling new instruments.

As to *Instruments and Automation*, Cal says "I have read it since about 1949. I feel that the most important feature of your publication is not the "Biography" section or even the feature articles, but the advertisements and descriptions of new products. Knowing what is wanted is an important part of instrumentation, but knowing where to get it produces successful installations."*

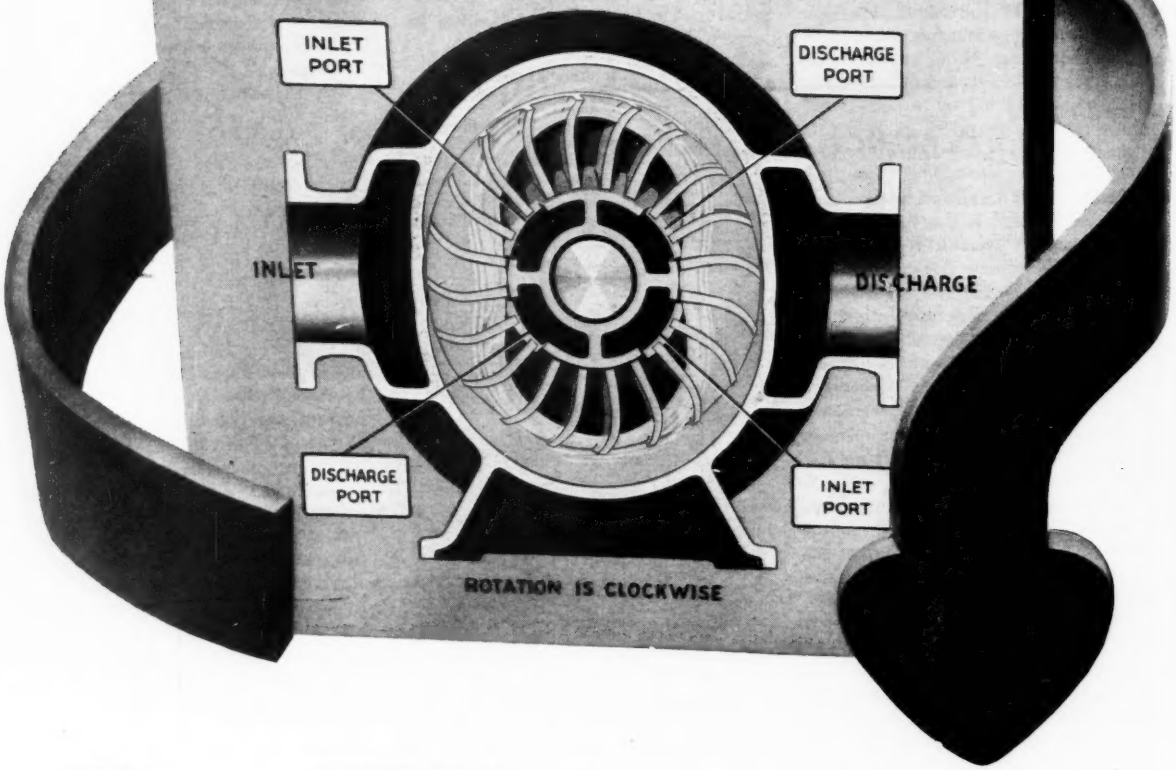
Much of Cal's time is spent in consultation with research project leaders at the start of the project on planning the mechanical set up for the work. He also often finds himself helping run down trouble; often answers his phone to hear some researcher or technician on the other end of the wire say "Come on over Cal. This thing won't work."

Cal is something of a homely philosopher as well as an artisan. Some of his views sum up well some present situations in the instrument field. He observes, for example, that "Instrumentation, more and more, is a matter of getting smaller and smaller differences between bigger and bigger numbers." He says that some instrumentation requirements are like trying to determine the number of ships in the ocean at any one time by measuring the rise in sea level. Cal also sadly observes that "Every instrument I have ever built is also a thermometer."

In his spare time Cal used to fool with electronics. For example, during the war and long before television sets were available, he made a TV set —using a 1-inch picture tube. Now for relaxation he spends weekends and any other available time aboard his 26-foot boat with his wife and 15-year-old daughter.

*I & A is the only publication that reviews more than 2000 new instruments annually.

Nash Instrument Air Compressors deliver only clean air, free from oil or dust, and without filters



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You can dispense with oil filters and dust filters when you install ®Nash® Clean Air Compressors. You can save the cost of maintaining these devices. You can greatly reduce instrument maintenance costs. For the Nash employs no internal lubrication, therefore no troublesome oil is in the delivered air. Moreover, air from a Nash is thoroughly washed and cooled as it passes thru the pump. Dust in the plant atmosphere, even fly ash, is immediately removed.

®Nash® Clean Air Compressors are simple, with only one moving element. No valves, gears, pistons, sliding vanes, or other enemies of long life and constant performance complicate a Nash. No aftercoolers are needed. You will find it profitable to investigate these pumps, now.

No oil filters.
No dust filters.
No internal lubrication to contaminate air handled.
No internal wearing parts.
No valves, pistons, or vanes.
Non-pulsating pressure.
Original performance constant over a long pump life.
Low maintenance cost.

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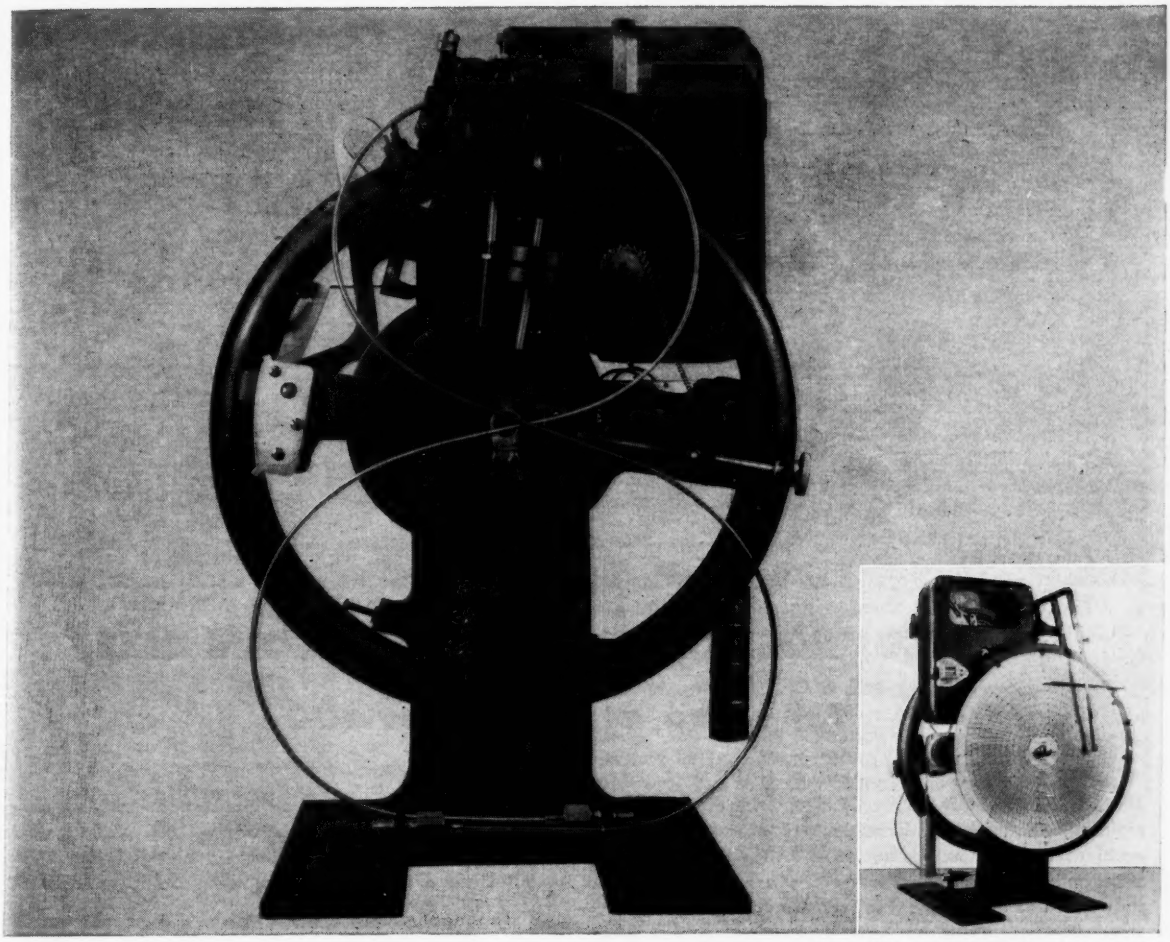

Recording and integrating Model 2656
(case removed)

Simple, direct action makes

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Simple, direct action and sturdy construction assure dependable, trouble-free service in Hagan Ring Balance Meters. The famous Ring Balance principle produces high accuracy, even at low differentials and at low rates of flow.

Hagan Ring Balance Meters are available for any gas or liquid flow measurement. Check these many outstanding features and see how they can help you get accurate and dependable metering with really low maintenance.

- **Calibration of meter may be checked with dead weights in a few minutes, without disconnecting the meter from the line.**
- **No stuffing boxes are used in Ring Balance Meters.**
- **No mechanism in contact with fluid being measured.**
- **The differential measuring range of any ring is readily adjustable over a 7 to 1 ratio.**
- **Calibration is independent of the amount of sealing liquid.**
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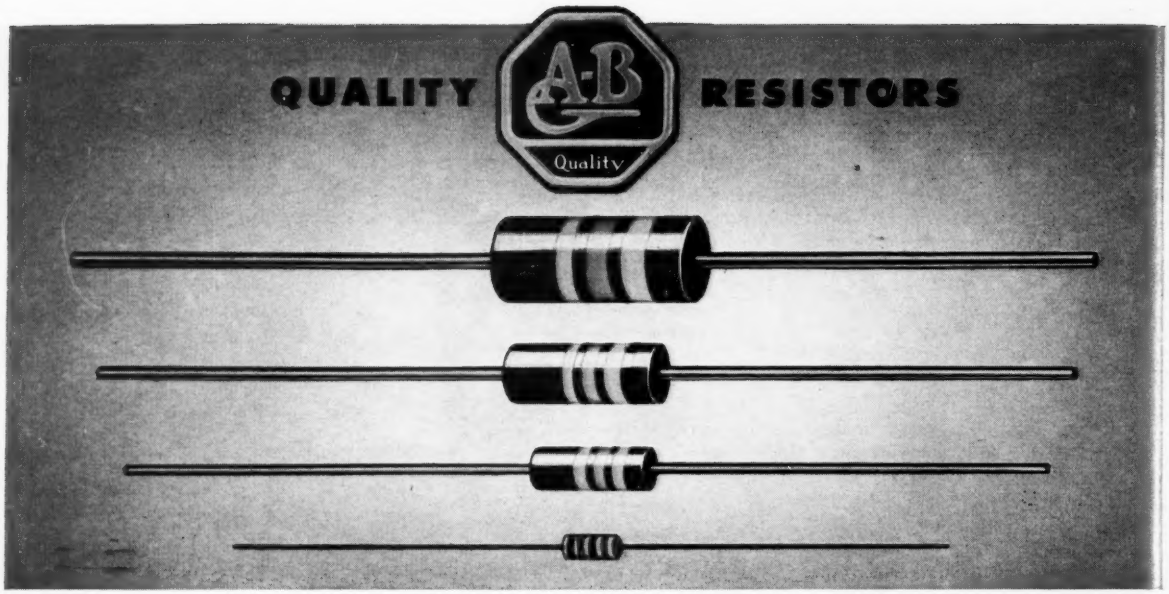


FIXED COMPOSITION RESISTORS IN FOUR SIZES

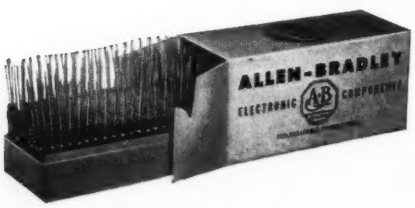
All rated at 70C — not 40C

There is an EXTRA MARGIN OF SAFETY in Allen-Bradley molded fixed resistors, because they are rated at 70C ambient temperature . . . not at 40C. These resistors can withstand extremes of temperature, pressure, and humidity without deterioration. They require no impregnation to pass salt-water immersion tests.

Allen-Bradley fixed resistors are available in 4 sizes... Type HB—2 watt; Type GB—1 watt; Type EB—1/2 watt; and Type TR—1/10th watt, in standard RETMA values from 10 ohms to 22 megohms. Their close dimension tolerances are an outstanding advantage when used in automatic assembly lines. The color coding does not chip.

For applications where resistors must not fail, use Allen-Bradley. Of course, they are also "the best" for all uses . . . and they cost no more than ordinary resistors. Send for Allen-Bradley resistor data.

Allen-Bradley Resistors Are Packaged in Cartons and on Reels



Allen-Bradley fixed resistors are furnished, as standard, in patented cartons. They can also be supplied in reels for automatic assembling equipment.

The resistors are aligned on a narrow, pressure-sensitive tape and wound on a fiberboard reel with a 9/16-inch mandrel. A lateral pull on the resistor leads detaches the units from the tape.

Reels contain from 1,000 to 2,500 units per reel, depending upon the size of the resistor. If automatic assembling is one of your problems, it may pay you to investigate the reel-packaging of A-B QUALITY resistors.

Allen-Bradley Co.
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In Canada—Allen-Bradley Canada Ltd.
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Allen-Bradley resistors on fiberboard reel for automatic assembling lines. Reels contain from 1,000 to 2,500 units.

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Rocket Engineering?

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At its new Canoga Park headquarters, ROCKETDYNE is continuing and expanding its pioneering work in the design, development and manufacturing phases of the rocket engine business. And at its test laboratory, ROCKETDYNE has complete research and test operations. ROCKETDYNE thus offers opportunities in the complete range of rocket engine development from preliminary design to field testing.

ROCKETDYNE not only offers the advantages of a constantly growing and expanding company, but also the stability that comes from its broad range and volume of projects... the stability of rocket engine contracts with all branches of the Armed Services and the guided missile industry. Though it is currently emphasizing the production of the most powerful large liquid-propellant rocket engines in the Western World, ROCKETDYNE is also designing, building, and testing many other types and sizes. For the future, it is carrying on research for even more powerful and startling rocket engines.

So this is your big opportunity to build a career that really has a future. A well-paid career that assures prestige, stability, and selectivity of fascinating work. If you feel you can qualify, you owe it to yourself to contact ROCKETDYNE today.

*ROCKETDYNE is North American's rocket engine division. It has just moved into new ultra-modern headquarters in Canoga Park, located in the beautiful West San Fernando Valley of Los Angeles. This area is famous for its fine residential sections, modern shopping-center convenience, varied recreational and entertainment facilities. Any point in the San Fernando Valley is just minutes drive from the beaches, and the weather is pleasant all year 'round. Many engineers are interested in advance schooling offered by UCLA, only ½ hour drive from our laboratory.

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Application of automatic computers to investigate new methods of numerical analysis.

TEST ENGINEERS
Experienced on engine systems, combustion devices, turbines, pumps and engine instrumentation.

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WEIGHT ENGINEERS
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SPECIFICATIONS ENGINEERS
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Write Mr. Joe Roberts, Rocketdyne Engineering Personnel, Dept. 596-IA, 6633 Canoga Ave., Canoga Park, California.

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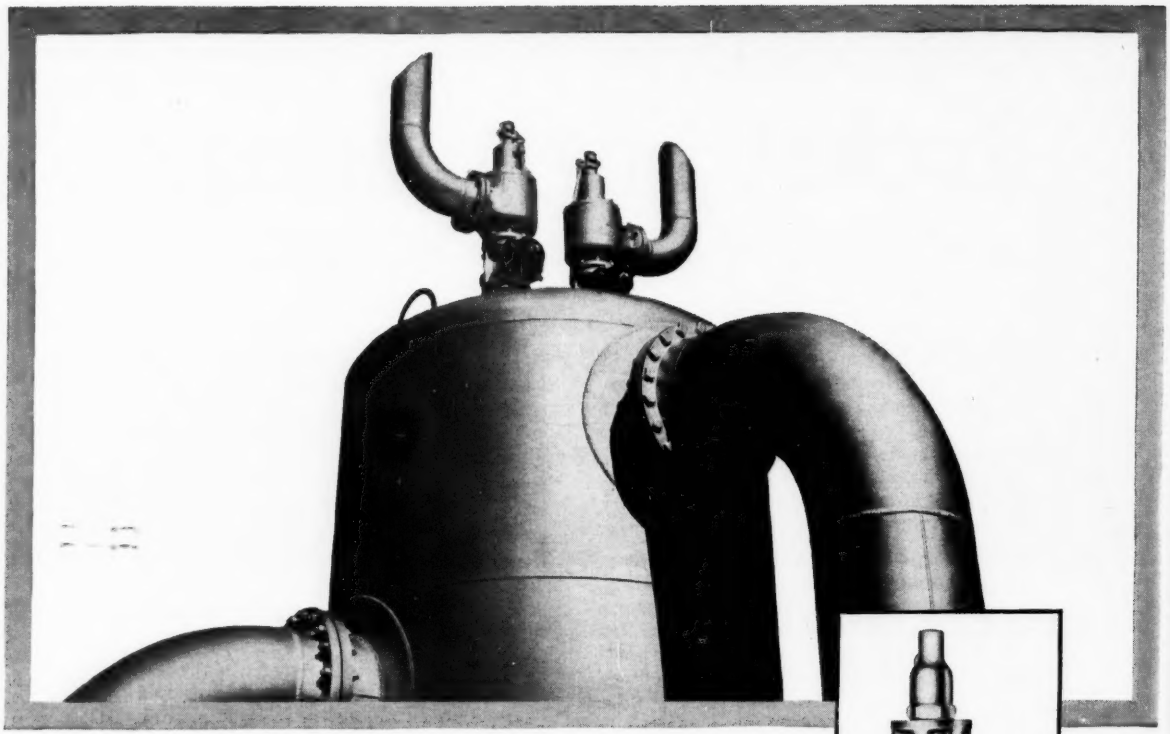
A DIVISION OF NORTH AMERICAN AVIATION, INC.



★ Economical "2 in 1" Design
★ Peak Performance
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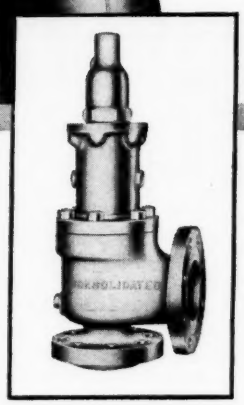

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Consolidated Safety Relief Valves satisfy *every* requirement of the most advanced processing facilities. Valve action is *consistently* positive. You get peak performance even where discharge lines are long or there is low "superimposed" back pressure in the relieving system!

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CERTIFIED AND APPROVED. Both Standard and Bellows Valves are approved under API-ASME and ASME Unfired Pressure Vessel Codes and are certified by the National Board of Boiler and Pressure Vessel Inspectors.

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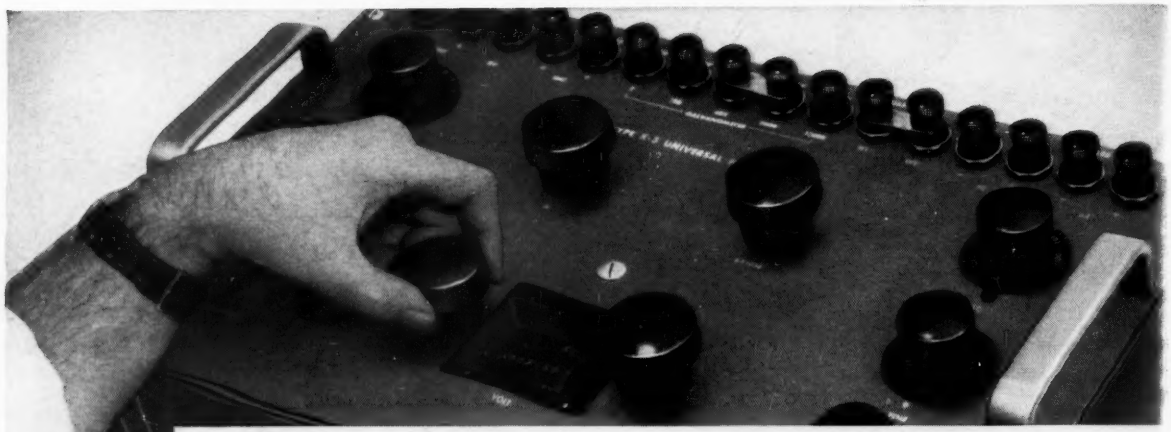

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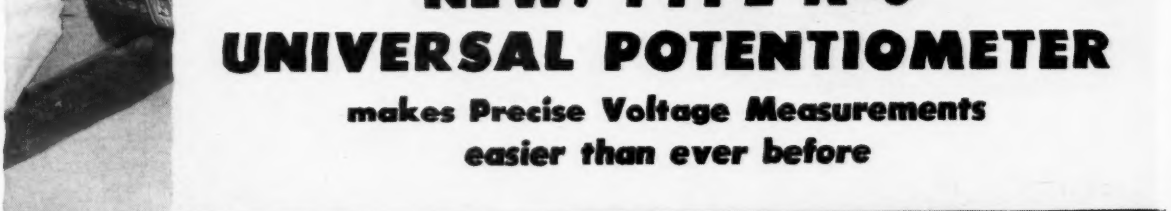

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INSTRUMENTS and AUTOMATION

Editorial

Automation, Revolution and Insight

THE word revolution, or revolutionary, has been applied to almost every facet of modern instrumentation—closed-loop control systems, dynamic frequency analyzers, automatic data loggers, servomechanisms, electronic controllers, computers, and others. It is common practice for the speaker or writer on the subject of automation to conclude his thesis with a picture of a manless plant being controlled by a computer receiving data automatically from a logger. As this picture is exciting and different, and as each of the developments therein—computer, data logger, etc., —is important to the evolution of production processes, the expositor has had no difficulty in developing his "revolutionary" theme.

The result has been a debasement of the word "revolutionary."

The word revolution, as defined in Funk & Wagnall's New Standard Dictionary, is "an extensive or radical and usually sudden change in anything; a total change, as of character or ideas." Thus the word should *not* be applied to refinements in technique; to evolutionary developments that merely advance the art by incremental improvement. It should be reserved for use where there is a "total change, as of character or ideas."

In this sense, what *is* revolutionary about our field of instrumentation and automatic control?

The obtaining of data, rapidly and efficiently, has been of prime importance since the earliest days of instrumentation. Every production process rests on a firm foundation of accurate, adequate, and timely information. Each increase in accuracy and rapidity of data gathering has permitted corresponding increases in production efficiency. As Glen Gallagher points out in his provocative article in this issue, the automatic data logger will make possible still greater efficiency in the continuous process. But this has always been so in connection with each improvement in data handling; this is evolutionary *and important.* But it is not revolutionary.

It is not necessary to dwell at length on the long history and great application of closed-loop control, servomechanisms, feedback, etc., to prove that these are old, well-established and conventional techniques in every field of engineering and industry. The only recent "total change" associated with these subjects has been in the minds of the general public and others discovering these fields for the first time. This is not enough to justify the word revolution as applying to these aspects of automation.

Perhaps most of the eloquence on the revolutionary implications of automation has been reserved for the computer, with millions of words being expended in propounding the limitless production possibilities of the manless computer-controlled plant. The imagination-staggering figures on the speed at which an electronic digital computer can add 1 and 1 have been used to paint glorious pictures of computers receiving data of all sorts and using the data to supervise the many controllers within the plant to the end of optimizing control. Despite the apparent newness of this picture, neither the objective nor the techniques in this picture represent a "total change." The number of individual production loops that are already closed by automatic controllers is in the order of thousands; special-purpose controllers are today controlling individual production processes in hundreds of plants and factories; continuous processes already use an "almost irreducibly low number of men," says Glen Gallagher in his article in this issue. Even if computer control of more or larger operations were to become economic in the near future, there would still be no "total change in character or ideas," and hence nothing revolutionary.

Thus it appears that most of what is today called revolutionary is not revolutionary but, rather, evolutionary technological development of our field.

The reason for this attempt to distinguish the evolutionary from the revolutionary is not to "debunk" the vast amount of public utterances, nor even to restore perspective—although it would be to the good were this to occur. The major objective has been to lay a firm foundation for a discussion of a development that does represent "total change," that does open fields of entirely new character, that is truly revolutionary.

The development is the analog computer. It is, specifically, the power of the analog computer as an *analytic tool* in gaining understanding of, and insight into, the production process. The revolutionary implications of the analog computer are associated with the revolutionary power of insight.

INSIGHT is defined in Funk & Wagnall's New Standard Dictionary as "power or faculty of immediate and acute perception or understanding; penetration; intuition; a perception of the inner nature."

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It is much different than understanding alone. One can understand many individual situations and yet lack insight into the true cause-and-effect relationships within those situations. The insight into the human mind that resulted from the theories of Freud has revolutionized not only the science of psychiatry but other branches of medicine as well. Insight into controlled processes will do as much for industry.

How is this possible? What does insight do?

Insight distinguishes the real causes from the many apparent ones that always becloud every complicated situation. It establishes, both qualitatively and quantitatively, the true roots and motivations, rather than the superficial ones. It pierces the devious complexity of many inter-related factors to point out the significance of each factor. The industrial engineer will at once recognize the power behind this type of analysis as applied to the complications of closed-loop industrial control systems with their many inter-related unit processes plus control mechanisms.

Until the advent of the analog computer, insight-type analysis of control situations was attempted purely mathematically. This work has been important and will continue to be so. But it has been reserved for the relatively few theoretical men with the necessary mathematical abilities, and even these men have had little success with integrated operations. Weldon H. Brandt* of the Westinghouse Electric Corporation, who recently toured Russia in an exchange arrangement for the study of automation, reports that the Russians believe it impossible to set up a mathematical description of chemical and petroleum processes to permit design of a truly automatic process. Many of our theoreticians agree. But the analog computer will permit an adequate empirical description, and it will do so for every plant engineer who wants it.

The analog computer offers insight into technical matters of all types—into individual equations, into inter-related systems of equations, into industrial processes defined only by simple transfer functions, into the processes integrated in closed-loop control systems.

Let us consider the importance of just the simplest of these matters, the linear differential equation with constant coefficients. Generations of engineers have graduated from colleges with the idea that such equations are textbook chores, hurdles to be overcome on the way to a degree. Only here and there was there an occasional college instructor or student who obtained insight into the equation and feel for its significance, who saw in the equation a picture of a dynamic physical situation.

*We will bring you Mr. Brandt's reflections on his trip next month.

This will not be so in the future—because the first equation given to a college student will be pictured (and the word is used both literally and figuratively) on an analog computer. At that instant the equation will take on meaning; each constant will reveal its significance; the order of the equation will become apparent physically. A new type of engineer will be born on the spot.

The college mathematics instructor who fails to use this tool in his class will do disservice to his students—and the engineer who fails to use this tool to gain inner knowledge of his plant will do disservice to his organization. The pathway to true inner knowledge has opened in industrial instrumentation and control. In the past this path has been open only to those few gifted individuals whose knowledge of mathematics permitted them to do complicated analyses of closed-loop control situations, an even then only partly open. The path is now wide open to all engineers who learn the techniques of simulation and analog computation. This is truly a "total change, as of character or ideas."

MHA

* * *

Dear D.R.*

We hope this issue finds you well and happy this month—and with enough time to relax over several important items.

First, the article on the LGP-30 by Stan Frankel and Jim Cass is a powerful introduction to the field of digital computation. It tells why a magnetic drum is made a certain size, how the words are put on the drum, how the instructions are entered, what they do, and how the program is designed.

It ties in beautifully with this month's installment of the important *Digital Automation* series by Klein, Williams and Morgan. If you have missed any of these articles we suggest you consult your files or library immediately. From our mail we know that we are not alone in thinking this material the best ever produced to date on the general subject of digital techniques.

We want also to point out the significance of Chet Beard's résumé of the various formulations on valve sizing and C_v. This article will clear up the questions in the minds of all you process men who have wondered why the equations in valve catalog A don't look like those in catalog B. And you process control men might also ponder a bit over our editorial on Insight. Read about the Ramo-Wooldridge Analog Computer Facility in the Simulation Council Newsletter this month after reading the editorial. Let's not let the missile and aircraft group carry this ball forever.

Cordially
Milt and the Editors

*Dear Reader

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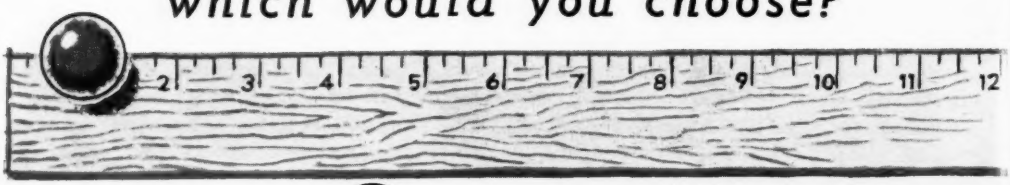

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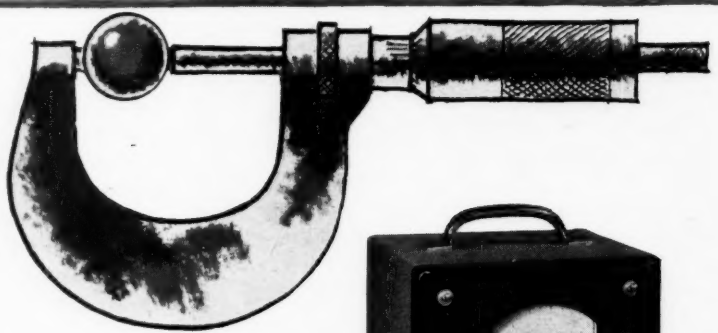

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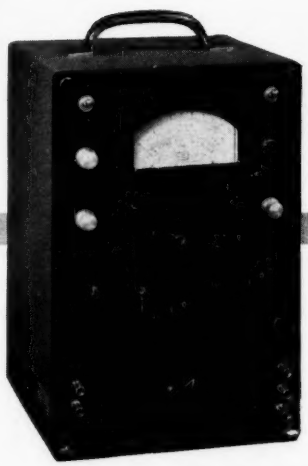

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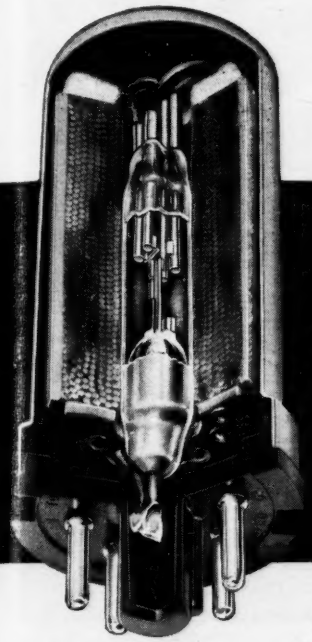
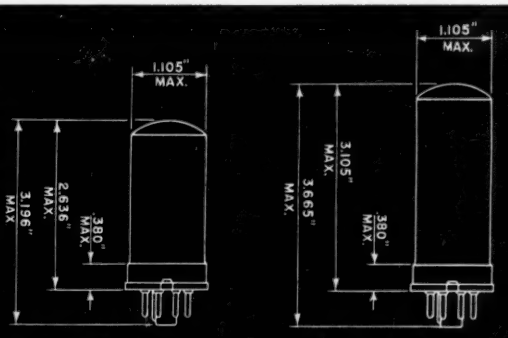


• Cutaway view showing sealed-in-glass, mercury-wetted contact switch, surrounded by the operating coil and encased in a metal housing mounted on an octal base.



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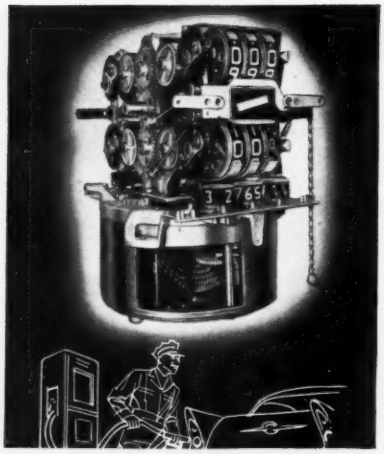

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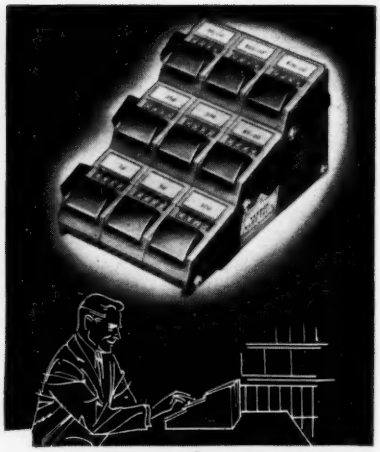

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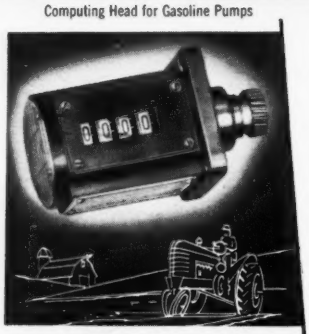

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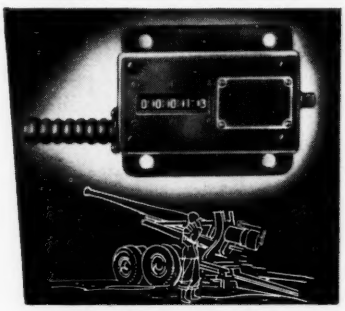

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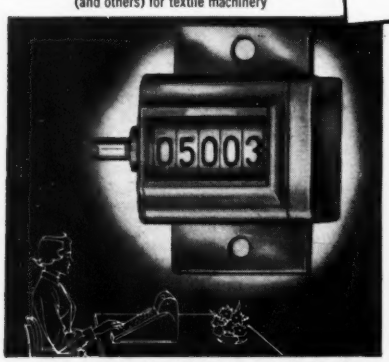

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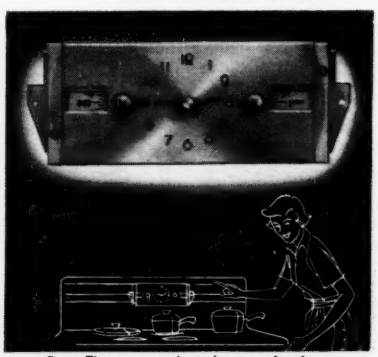

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Historical Introduction

MANY early digital computers were planned to perform fairly specific tasks. An example is ENIAC (Electronic Numerical Integrator and Computer), completed in Philadelphia in 1946. It was the first of the large-scale electronic digital computers. ENIAC was built to compute shell trajectories and prepare firing tables. It was, by present standards, a very limited machine. It held the numbers involved in its calculations in ten units called "accumulators," each of which could hold a ten decimal digit number and its sign, and also had a certain degree of arithmetic ability. Arithmetic operations were performed by passing numbers back and forth among these ten accumulators. The successive operations were controlled by auxiliary units called "program control units." For each operation two or more of these came into action and took over control of some of the accumulators and/or various other operational units. Instead of interconnecting the program control units in a permanent fashion to determine the entire sequence of operations, it proved more convenient to provide plug wires by which they were interconnected. As a result of this plug-wire system of interconnection, ENIAC proved to be a much more widely useful machine than its original directive called for. There were, however, two essential limitations on the class of problems it could handle, both having to do with what we might call its "memory capacity." It could only "remember" ten numbers and about one hundred steps of instruction. Complex problems could not be fitted to this limitation.

In the period following the completion of the ENIAC, designers tried to provide greater flexibility by seeking various kinds of bulk memory storage, both for numbers to be operated on and for the instructions which were to control these operations. It soon proved possible to provide memory devices holding a few hundred to a few thousand numbers, using equipment no more complex than was required for ENIAC's memory of ten numbers. There then remained the problem of providing capacity for the storage of a great many instructions. It was soon recognized that instructions could be stored in coded form in the same way that numbers are stored, and in the same devices. The computer can then be allowed to draw these instructions from the memory store one by one, as needed. These two developments broke the bottleneck of memory capacity, and made possible computers capable of performing almost any imaginable kind of arithmetic calculation.

Most of the large-scale electronic computers that followed ENIAC are of such flexibility that they have come to be called "general-purpose" computers. At first, it might appear that the finite, though large, memory capacity of each machine would impose a definite limit on its range of use. As we will show later, that limitation is easily evaded, so that any such computer with a large memory is just as flexible as if its memory capacity were infinite. Since that limitation can be evaded, these general-purpose computers may justifiably be called "universal computers" in the sense introduced by A. M. Turing in 1936. The word "universal" is not used idly. It is difficult to say precisely how broad is the "universe" of computable problems, chiefly because it is difficult to describe a process which could be called a "computation" which could not be performed by a universal computer.

Necessary Operations of a General-Purpose Computer

The process of setting up a general-purpose computer to carry out some desired process consists of choosing and setting into the computer's memory an appropriate sequence of instructions and numbers; its *program*. Each instruction causes the machine to carry out one of its basic operations. The process of planning such a sequence of instructions is called *programming*. We now consider the question of what must be included in the set of elementary operations available for choice; in other words, what should be the vocabulary of the language of the computer.

The vocabulary must include some arithmetic operations. The computer must be able to add, subtract, multi-

Presented at the Computer Clinic, Second International Automation exposition, Chicago, Nov. 14-17, 1955.

Fig. 1. The LGP-30 general-purpose digital computer is a mobile, serial, single-address, stored-program digital computer.

ply, divide, extract roots, form logarithms, exponentials, etc. However, not all of these need to be included in the vocabulary of elementary operations because the more complex operations may be built up as sequences of elementary steps. Most computers now include only the first four of these operations—add, subtract, multiply and divide. In a few computers some further processes have been included (e.g., ENIAC included square root), in some others less than this set has been used (e.g., one high-speed electronic computer does not have built-in division). The fewer arithmetic processes a computer is required to perform as elementary operations, the simpler its design can be. On the other hand, additional elementary operations may prove a convenience to the user and can increase the over-all speed of computation. It is generally considered that the inclusion of the four primary arithmetic operations provides a good compromise between these conflicting pressures, and that is the choice made in the design of the LGP-30.

Let us consider a situation in which an addition is to be performed. The computer reads from its memory an instruction which includes the order, ADD. That alone is not a complete instruction. The computer must also be told what two numbers are to be added. In the LGP-30, as in many general-purpose computers, one of the two numbers is that which is held in a specialized unit of the memory called the *accumulator*. The second number is designated by including in the instruction a specification of the part of the memory in which it will be found. The memory is divided into units, called *words*, each of which is identified by a number called its *address*. One address is included in each instruction to identify one of the two numbers used in the arithmetic process. The other number is that previously held in the "accumulator." At the end of the operation the arithmetic result shows up in the accumulator. This method of specifying operations is called a *one-address code*. Other systems using two or more addresses in each instruction have also been used widely.

As the number resulting from an arithmetic operation is not always to be used immediately in another arithmetic process, some means must be provided for placing the number held in the accumulator in storage in the general memory. This is done by RECORD orders.

After an operation has been completed, the computer must read from its memory the instruction which is to be obeyed next. Some system must be provided for determining where that next instruction will be found. In many computers the system normally used is that the instructions to be obeyed in sequence will be found in successively numbered memory locations. However, some exceptions must be provided to this normal sequence of instruction words. These are provided by CONTROL TRANSFER orders. Such an order includes an address at which the next instruction will (or may) be sought. Various sorts of *conditional control transfer* orders are provided, which do or do not effect this transfer, depending on the results of previous calculations or on external circumstances. The conditional control transfer orders permit the computer to make "decisions"—that is, to follow one or another course of action depending somehow on information at its disposal.

We have now described all of the operations essential to the internal economy of a general-purpose computer, including (1) arithmetic operations, (2) control transfer to obtain instructions, and (3) record the results for the next operation. In addition, some means must be provided for setting numbers and instruction into the computer memory before it starts its work, and some way for it to report out results. A great variety of such "input-output" mechanisms have been used. Results of calculations, or intermediate data, may be pumped out on punched paper tape, on magnetic tape, punched on cards, etc., or may simply be typed on paper, and may at a later time be re-inserted into the computer if further processing is required. As there is no limit to the number of rolls of tape or sheets of paper which could be provided, we may regard the available memory capacity of any general-purpose computer as indefinitely large. It is this theoretically infinite memory capacity which justifies our calling these computers "general purpose." Any such computer is a "universal computer" in the sense defined by Turing; that is, it can perform any computation which could be performed by any computer whatsoever.

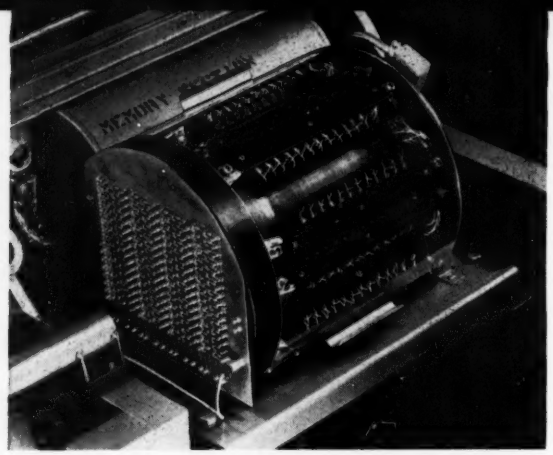


Fig. 2. The magnetic-drum memory has 64 heads, each of which can record 64 words of information on its track, giving a bulk memory of 4096 words. As drum rotates at 3600 rpm, any word is accessible in 17 ms—but special interlace feature for minimum-access-time coding reduces usual access time to 2 ms.

Practical Criteria for General-Purpose Computers

This universal quality of general-purpose computers might at first sight make it appear that all general-purpose computers are equivalent and interchangeable. Various practical considerations modify this apparent equivalence. Perhaps the most important of these is speed. If you have a definite problem, it may be important to you whether a computer can solve it in an hour or a week. For example, we have substantially all of the theoretical background necessary to enable us to predict tomorrow's weather on the basis of today's observations. The prediction would be of little use if it came a week late.

A second practical distinction to be drawn between various computers is the ease with which problems can be prepared for solution. Preparing a problem for a general-purpose computer ("programming") is a process requiring skill and patience. The labor of programming often represents a major part of the cost of problem solution. To minimize this cost, it is desirable that the code of a computer be simple and conform to accustomed ways of thinking.

A third practical consideration bearing on the merit of a computer is that of cost. If two alternative computers were equally able to do a job, the less expensive of the two would be preferred. One important aspect of the cost of a computer is that arising from maintenance requirements.

Aside from breakdowns, another aspect of reliability is the frequency of occurrence of isolated or sporadic errors, worst of all being undetected errors. On this score an extremely high level of reliability is required to make a computer satisfactory. For example, we might imagine a computer which "drops a stitch" about once in a million times. Although this computer might be called 99.9999% reliable, it would in fact be worse than useless.

One of the ways of increasing computer reliability is by cutting down the number of components subject to error or breakdown. Of course, the reliability of a computer is not to be measured only in terms of the number of components subject to breakdown, but also by component reliability. On this score great progress has been made in the past few years. The development of long-life computer tubes, of glass sealed diodes, of printed circuits, and so forth, has permitted us to raise our sights spectacularly regarding standards of reliability. Whereas a few years ago we thought of an error-free running period of a day as encouraging, we may now hope for months or years of trouble-free operation.

Nevertheless, if two computers are designed with equal skill in the choice of components and methods of using them, it is to be expected that the machine with the smaller number of components will have the greater reliability. It is probable that this consideration, as much as consideration of price, has motivated the trend toward simplication of design of digital computers in the past few years. When we describe the LGP-30 in particular we will not boast about how many tubes it has, but rather of how few.

How is it that the current crop of general-purpose computers require far fewer components than the earlier machines? One reason is simply the general improvement of technology and the greater fund of experience available to the computer designers. For example, ingenious methods have been developed which give increased speed of operation at little or no cost in increased complexity. Another important advance is the development of sophisticated methods of mathematical representation of the internal activities of a computer, which permit a designer to treat the entire computer as an integrated unit rather than having to break it up into compartmentalized sections, each of which is designed separately. In this way much duplication of equipment has been avoided. Where the earlier computers used a large number of components each called into action only occasionally, present computers use a few components, each doing useful work most of the time.

Another way in which the prevailing mode of computer design has made progress is that communication between the designers and the users of digital computing equipment has improved. Many types of computers have been built, and experience in their use has accumulated. We are able to benefit from this experience by making sounder estimates as to which of the possible features of a computer are really essential to convenient and efficient operation, and which are inessential embellishments which can be eliminated profitably.

Functional Design of LGP-30

We will now turn our attention to a particular general-purpose computer, the LGP-30 (Fig. 1).

Perhaps the most fundamental choice in the design of a digital computer is that of its memory unit, which usually involves the bulk of the hardware of the computer. The LGP-30 computer makes use of a magnetic drum (Fig. 2)—that is, a rotating cylinder coated with a material on which information can be recorded magnetically. At the present time this is, by a wide margin, the simplest method by which a considerable bulk of information can be stored so as to be available for use in times of the order of a hundredth of a second. We use a number of "heads" which record and recover information. Most of these heads serve both purposes, recording and reading. Each head makes use of its own "track" on the drum, in which 64 words of information are recorded. Sixty-four heads are used, thus providing a bulk memory of (64 x 64), or 4096 words. The comparative adequacy of this size for the internal memory is shown by the fact that many high-powered (and high-priced) computers operate with considerably less. A memory capacity of less than, say, one thousand words would severely limit the utility of a computer, a capacity of four thousand odd words provides a comfortable margin for most types of

problems. Of course, a still more capacious memory would be even more comfortable; however, 4096 words puts us well into the region of diminishing returns. Fortunately, we have been able to find ways of providing this relatively large memory without uncomfortably increasing the overall complexity of the computer.

The drum is turned at a rate of about 3600 rpm; thus a word stored anywhere in the memory is accessible in no more than 17 milliseconds. As our later discussion will show, a considerably shorter time, about 2 ms, is in practice a more typical "access time."

Words

A word consists of 32 bits (binary digits) placed in succession in one track of the drum. This way of recording information is called "serial," and its choice is dictated by our requirement of simplicity.

A word of the memory may represent either a number or an instruction. When an instruction, there are 4 bits devoted to *order*, and 12 to *address* (one address per instruction).

The numbers are represented in binary, actually fractional binary. That is, each bit represents a number 2^{-n} (rather than 2^n as in straight binary). Thus 30 of the 32 available bits represent all numbers down to 2^{-30}, or approximately 1 billionth. Of the two remaining bits, one is used to specify whether the number is positive or negative; the other serves merely as a rest or "meditation period" at the end of each word. (It is interesting to note that this fractional binary system is really a familiar one—more familiar than the word itself. For example, the ordinary ruler has subdivisions of an inch—a half, a quarter, a sixteenth, etc.).

There are two reasons for the choice of the binary system. One is that it is the most efficient way of using the memory capacity. If, for example, the "binary coded decimal" representation were used, the 30 bits available for indicating the magnitude of the number would be two more than necessary for seven decimal digit accuracy (and two short of enough for eight decimal digits), whereas in the binary system they provide slightly better than nine decimal digit accuracy. The other, and more important, reason for using the binary rather than decimal system is that it considerably reduces the complexity of the number-handling mechanisms. Many digital computers have been designed to operate in an internally decimal (or, more strictly, quasi-decimal) fashion because it was felt that this provided some added convenience for the operator, who presumably feels more at home in the decimal than in the binary system. We felt in designing this computer that that convenience would be outweighed by the disadvantages of the necessary increase in complexity. In this connection it should be noted that in normal use the operator seldom needs to be aware of the binary internal character of the computer; he delivers numbers and instructions in the decimal system and reads decimal answers. The translation into and out of the binary system is performed by a permanent input-output routine which has been prepared in advance.

Input-Output

The input-output device which we have chosen is the Flexowriter. This is an electrically operated typewriter which is equipped to produce, and to be operated by, punched paper tape. This punched tape serves as an external medium for the storage of information. In preparing a problem for the computer, the Flexowriter is used to make an input tape. This may be done in part by directly typing in data and orders, in part by copying and editing such previously prepared tapes as may be useful in the problem at hand. When the problem is to be run, the input tape is put into the Flexowriter, which feeds its information into the computer and simultaneously produces a typed copy for verification. After the input tape has been "read," the computer normally takes over control of the Flexowriter to type out answers or to type and punch on tape data to be reintroduced at a later time. The computer can exercise full control over the Flexowriter so that it can be used to write its results in any desired format, or to type any headings or explanatory material which the Flexowriter is equipped to type.

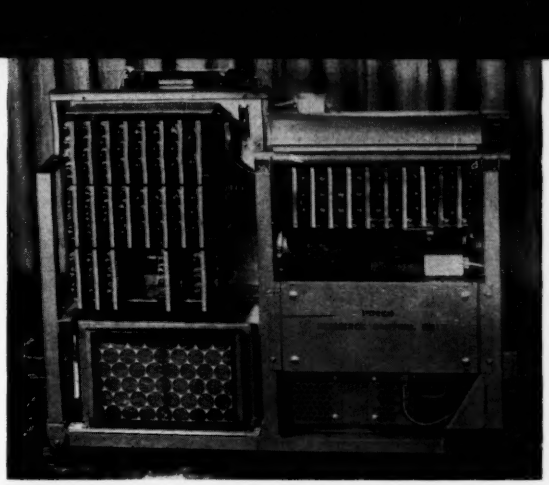


Fig. 3. Rear view of LGP-30, with cover off. Unitized circuits are on etched circuit cards.

Order Structure and Code

Each word placed in succession on each track of the drum contains 32 digits if a number, or 16 digits if an instruction (4 devoted to the specific command order, and 12 devoted to address). The instructions command the computer to perform its built-in operations; the addresses refer to the locations where the number is to be found. The result stays in the accumulator.

We have discussed the various elementary operations performed by all general-purpose computers. Each operation is represented by some symbol or code which may be held in the memory of the computer and causes it to perform that operation. The set of such symbols for a particular computer is its *order code*. As we have seen, a small list is (in principle) sufficient to permit a computer to call itself "general purpose." Usually many more than the necessary minimum number of orders are included for the sake of speed and convenience of operation. The choice of this list results from a compromise between the conflicting aims of simplicity and convenience.

The LGP-30 has a simplified command structure of 16 orders, which are designated on the electric typewriter by a letter and in the machine by a corresponding code number. Table 1 shows the 16 instructions, including code, typewriter letter, address, and explanation. The address *m* refers the machine to the memory location at which the operand may be found.

The LGP-30 has three registers: a *counter register* (control counter) to designate the next instruction to be obeyed, an *instruction register* to hold the instruction being executed while the address is being searched, and an *accumulator* in which the arithmetical operation takes place. One of the operands is always the previous occupant of the accumulator; the result always appears in the accumulator. The second operand is identified by the address which accompanies the order in an instruction.

Fig. 4. Logic board contains necessary gating circuits.

Table 1.—Instruction Order List Showing Code for Each Instruction

	Code	Instruction	Effect
ARITHMETIC	0001	B m*	Bring. Clear the accumulator, and add the contents of location m to it.
	1110	A m	Add contents of m to the contents of the accumulator, and retain the result in the accumulator.
	1111	S m	Subtract the contents of m from the contents of the accumulator, and retain the result in the accumulator.
	0111	M m	Multiply the number in the accumulator by the number in memory location m, terminating the result at 30 binary places.
	0110	N m	Multiply the number in the accumulator by the number in m, retaining the least significant half of the product.
	0101	D m	Divide the number in the accumulator by the number in memory location m, retaining the rounded quotient in the accumulator.
	1001	E m	Extract, or logical product order—i.e., clear the contents of the accumulator to zero in those bit positions occupied by zeros in m.
TRANSFER CONTROL	1010	U m	Transfer control to m unconditionally—i.e. get the next instruction from m.
	1011	T m	Test, or conditional transfer. Transfer control to m only if the number in the accumulator is negative.
RECORD	1100	H m	Hold. Store contents of the accumulator in m, retaining the number in the accumulator.
	1101	C m	Clear. Store contents of the accumulator in m and clear the accumulator.
	0010	Y m	Store only the address part of the word in the accumulator in memory location m, leaving the rest of the word undisturbed in memory.
	0011	R m	Return address. Add "one" to the address held in the counter register (C) and record in the address portion of the instruction in memory location m. The counter register normally holds the address of the next instruction to be executed.
MISC.	0100	I	Input. Fill the accumulator from the Flexowriter.
	1000	P t	Print a Flexowriter symbol. The symbol is denoted by the track number part of the address (x).
	0000	Z t	Stop. Contingent on five switch ($T_1 \ldots T_5$) settings on the control panel.

*The address part of the instruction is denoted by m when it refers to a memory location, by t when only the track number is significant. For example, m might be 4732, meaning Sector 32 of track 47.

Arithmetic Orders

The four fundamental arithmetic operations—*add, subtract, multiply* and *divide*—are produced by orders represented by the symbols *A, S, M, D* (the symbols used by the operator and typed on the Flexowriter). Inside the computer they are represented by binary codes, as shown in the order code table (Table 1). Note that *Add* and *Subtract* are represented by fairly similar codes: *A* by 1110 and *S* by 1111. As the internal operations evoked by the two orders are similar, it proved possible to save in design by assigning them similar codes.

In some computers a separate special register, aside from the accumulator, is used to hold a multiplier or the quotient resulting from a division, or for various other special uses. This requires the introduction of special orders to fill that register or to recover numbers from it. Here we have chosen to adhere consistently to the more straightforward form used in the simpler orders: *one of the operands is always the previous occupant of the accumulator, the result always appears in the accumulator.* The second operand is identified by the address which accompanies the order code in an instruction. Thus, for example, the instruction *S* 4732 (as typed on the Flexowriter) means: "subtract the number found in sector 32 of track 47 from the number in the accumulator: keep the difference in the accumulator." (It is more convenient for the operator to identify words of the memory by track number and sector number—00 to 63—rather than by the word number—0000 to 4095.)

On the order *Multiply* the accumulator retains the sign and most significant 30 bits of the product; the remaining 30 bits of the product are discarded. As it is sometimes desired to make use of the less significant half of the product, an alternative multiply order is provided, denoted by *N*, in which it is the least significant 30 bits of the product which are retained. It is sometimes convenient to think of *M* as multiplication applied to fractions, *N* as the multiplication of integers.

One more operation is of partially arithmetic character. It is the order *Extract*, with the symbol *E*. It produces a (binary) digit-by-digit product of the two operand numbers. That is, wherever one number has the digit 1, the corresponding digit of the other number is kept; where it has an 0, the corresponding digit is replaced by zero. Thus a 1 occurs in the result only where both operands held 1's. Though not essential to the operation of a computer, it is useful in various ways. If, for example, several pieces of information of different meaning are stored in one word, the *Extract* order facilitates our later slicing them apart for separate use. An example arises in the use of stored function tables in which interpolation is to be performed. After an argument has been computed, it must be separated into an "integral" and a "fractional" part which are used in different ways. The two parts are easily separated by use of the *Extract* order.

Sometimes it is desired to bring a word from the memory into the accumulator without regard for the present accumulator content; that is, to clear the accumulator to zero and then add the indicated word. This is accomplished by the order *Bring*, denoted by *B*, as shown in Table 1.

Transfer Control Orders

These orders are useful when it is desired to interrupt the normal sequence of operations in a program.

Ordinarily the machine looks for its next instruction in the counter register, which counts forward by one as each instruction has been read. A *U* (unconditional con-

trol transfer order) replaces the address held in the counter register by the address accompanying such an order. Thus the instruction *U* 1234 does nothing to the memory location 1234, but sets the number 1234 into the control counter. Then the computer looks for its next instruction in memory location 1234 rather than in the place indicated by the normal sequence. This is one method by which the computer may be guided into subroutines.

Another order, *Test*, may replace the counter register content by its accompanying address—but only if the number in the accumulator is negative; otherwise the *Test* order is ignored. This order permits the introduction of branching of a sequence of operations, contingent upon results of computation (or on the setting of a switch on the control panel).

Record Orders

After a number has been formed in the accumulator as the result of one or more arithmetic operations, it may be necessary to store it in the memory for use at a later time. This is accomplished by either of two orders denoted *H* and *C* (Table 1). In some cases one wishes to make further immediate use of that number, in other cases one wishes to have the accumulator clear for other use. For this reason the two forms of the record order are provided: *H* is "store the accumulator content but *Hold* it in the accumulator," *C* is "store the accumulator content somewhere and *Clear* the accumulator." For short, these are called *Hold* and *Clear*.

Although we have spoken separately of numbers and instructions, the separation is not basic. It often occurs that one wishes to operate arithmetically on the address part of an instruction. A convenient way of doing this is provided by the order *Record Address*, denoted by *Y*. This causes the recording of just the address part of the accumulator content in the indicated memory location, leaving undisturbed the remainder of the word previously held in that memory location—presumably an order code symbol.

There is one more record order, *Record Return Address*, denoted *R*. Like *Y* it records only in the address part of the indicated word of the memory. The order part of that word is presumably a *U* order, and remains undisturbed. However, unlike all of the other record orders, the information recorded is not drawn from the accumulator but from the control counter. Specifically, the control address (which has already been increased by one since reading this instruction) is added to unity and recorded. The effect of this is to create in the operand word an instruction which refers control back to the second word following that in which the *R* order occurs. The *R* order simplifies the use of "subroutines" (sequences of instructions which do not form an integral part of the main sequence of operations but which stand off by themselves and may be used repeatedly at stages of computation). In using a subroutine, before taking control to its beginning, arrangements must be made to ensure that control is returned to the appropriate place at its end. This is handily done by the *R* order. To call a subroutine into action requires only two words of instruction—an *Rm*, and a *Un*, where *m* is the address of the end of the subroutine, *n* of its beginning.

Break Point and One-Operation Mode

Most discussions of electronic computers emphasize the extremely high speed with which the computer operates. Usually some such statement as this is made: "This machine can perform in two hours a computation which would take a mathematician *x* years." Such statements are misleading, since mathematicians are notoriously poor computers. The intent of the statement is, however, correct. Any computation the machine can perform the human computer also can, but he might take an unreasonably long time. The only essential advantage of the machine lies in its speed. The human computer is usually less expensive, uses less power, and may even be more decorative (when feminine).

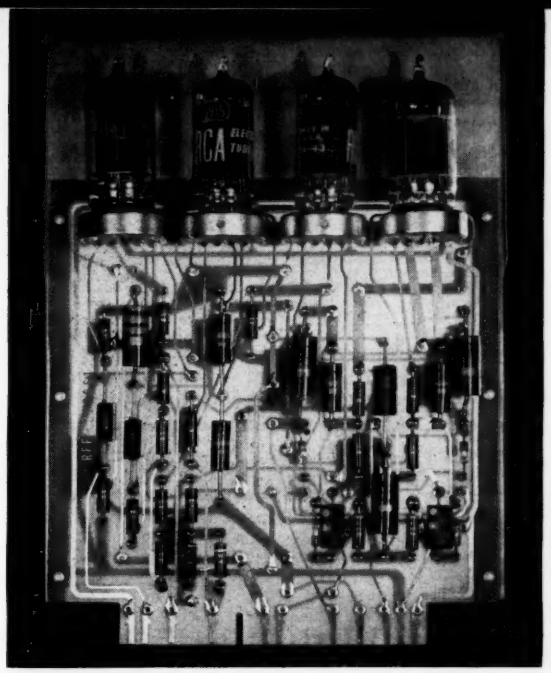


Fig. 5. Etched circuit card, showing one of the unitized circuits.

There are, however, some situations in which the high speed of the computer is not an advantage but a drawback. After a newly programmed problem of considerable complexity has been prepared and put on tape, it is presented to a computer which zips through the calculation at electronic speed and presents an answer; usually wrong. In that situation, it is possible that the computer made an error, but it is much more likely that the fault lies with the mathematician who prepared the program. In trying to track down the source of the error, he finds the high speed of the machine an embarrassment. It runs through the program too quickly for him to be able to see where it deviates from his intended path. Thus, he needs ways of slowing down the action of the computer so that he can make a step-by-step check on its behavior.

Two devices are provided in this computer to help the mathematician out of this difficulty. One is the provision of a *one-operation mode*. With the mode switch set to one-operation the computer executes only one step and then stops. It is restarted, to execute another step, by the start button. By repeatedly pressing the start button, the operator may "pedal through" the calculation at a slow rate. After each step the number held in the accumulator, the instruction just executed, and the address of the next instruction are visible on the display oscilloscope.

Provision of the one-operation mode does not completely solve the mathematician's problem. If the problem is one which will require many minutes for computation with the machine running continuously, it would take days to pedal through the entire program. This is not

LGP-30 Interlace Pattern

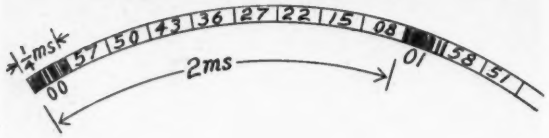


Fig. 6. Word 00 contains instruction 1. Word 01 contains instruction 2. However, 01 is placed 1/7th drum circumference away from 00, and 8 words are placed in the space between. This permits instruction 1 to apply to 6 of the 8 words between 00 and 01 before instruction 2 is reached—and permits a complete computer operation to occur in only 2.3 ms. Average access time can thus be reduced from 17 ms (one complete revolution of drum) to 2 ms.

because the program has a very tremendous number of instructions but because it has loops of instructions which are executed many times in the course of the problem. After the operator has pedaled through a loop once and verified that it performs as required, he needs some method of by-passing the later repetitions of that loop and examining in detail the performance of the next part of the problem. What is needed is a method of stopping the computer at selected points in the program to permit a local step-by-step examination. To satisfy this need, the Break-point order is provided. It is denoted by *Z*. The effect of a break-point instruction is to stop the computation, provided a *break-point switch* is open. If the switch is closed the instruction has no effect. By opening the switch and running in the continuous mode the problem may be brought up to the point where the first break-point order occurs; then by turning to the one-operation mode the part of the program immediately following that break-point can be examined.

The order *Print*, denoted *P*, provides the means by which answers are reported out on the Flexowriter. In some computers an instruction of this kind causes the typing out of an entire word; usually the word designated by the accompanying address. That is an excellent system, particularly if the computer is able to go on about its business while the typing is going on—but it has two drawbacks: One is that it gives little control over the format of the typed-out results. The other drawback is that it requires the use of a considerable amount of auxiliary equipment. We have chosen another system; namely, to control the Flexowriter directly by the computer without the use of intermediate machinery. Our Print order types just one symbol. The Print instruction is modified in its effect by the six digits of the track number of its address (as in the break-point order). Thus, there are, in effect, 64 different print instructions (although not all of these would be meaningful to the Flexowriter). These cause the typing of the decimal digits, letters, punctuation marks, shifts to upper case or lower case, tab release, carriage return, etc.

There is one more order code, called *Write-in* and denoted *I*. Its use is specialized to the input process; that is, the filling of the computer memory by the Flexowriter. Since the input "order" almost never occurs in ordinary programming, it should perhaps not be regarded as an order but rather as a specialized state of the computer used during the input process.

Table 2.—Efficient Program For Formation of Sine of Angle x.

Memory Location	Content	Effect	Memory Location	Content	Notes
0000	H 0043	x to 0043	0035	.00015148	C_9
0001	H 0044	x to 0044	0036	−.00467377	C_7
0002	U 0007	delay	0037		x^2
0007	M 0043	form x^2	0038	.07968968	C_5
0008	H 0037	x^2 to 0037	0039		x^2
0009	U 0010	delay	0040	−.64596371	C_3
0010	H 0039	x^2 to 0039	0041		x^2
0011	U 0012	delay	0042	.57079632	C_1
0012	H 0041	x^2 to 0041	0043		x
0013	M 0035	mult. by C_9	0044		x
0014	A 0036	add c_7			
0015	M 0037	mult. by x^2			
0016	A 0038	add C_5			
0017	M 0039	mult. by x^2			
0018	A 0040	add C_3			
0019	M 0041	mult. by x^2			
0020	A 0042	add C_1			
0021	M 0043	mult. by x			
0022	A 0044	add x			
0023	U	exit.			

Interlace Pattern for Optimum Address

One special aspect of the construction of the LGP-30 is important to the way programming is done for problems in which speed of calculation is important. As previously described, each track contains 64 words recorded around the circumference of the drum. These words are numbered 00, 01, etc., to 63. The normal sequence of orders follows this sequence of numbers; that is, after an instruction in word 00 is obeyed (if it is not a *U* or *Z* instruction) the next instruction is found in word 01 of the same track, then 02, etc. After word 63 comes word 00 of the next-numbered track. The numbering of words thus indicates the order in which they would be obeyed as instructions in normal sequence.

However, the words are not placed in succession on the drum—that is, word 01 and word 00 are placed one-seventh of a drum circumference apart to allow a 2-millisecond interval to elapse between successive orders. The space between the words 00 and 01 is devoted to 8 other words, as shown in Fig 6.

The purpose of this *interlace pattern* is to permit programming in a way to speed operations. For example, instruction 1 (in word 00) can instruct the computer to operate on any of the words between 00 and 01, and the operation can be performed before instruction 2 is reached in word 01. (Actually, words 57 and 08 should not be used—but any of the other 6 words can be used.) The problem may thus be planned and programmed so that the average access time is 2 ms rather than the 17 ms required for a complete revolution of the drum. Such planning is called *minimum latency coding*, or *minimum access time coding*. A circular slide rule has been prepared for optimum coding.

A Typical Program

The program shown in Table 2 is an efficient program, prepared by C. F. Flannell, for the formation of the sine of an angle, x. The angle (expressed in quadrants) is in the accumulator on entering the routine. thus the first instruction (in word 00) is to bring the angle x to location 43 on track 00, or to location 0043. The second instruction is to bring the same angle to location 0044 (so that the contents of 0043 and 0044 can be multiplied to give x^2 in the fourth instruction). The delay orders are merely "skips" to get to later optimum-coded instructions. The entire routine, shown in Table 2, gives the sine with about eight-decimal-place accuracy—in about 150 milliseconds.

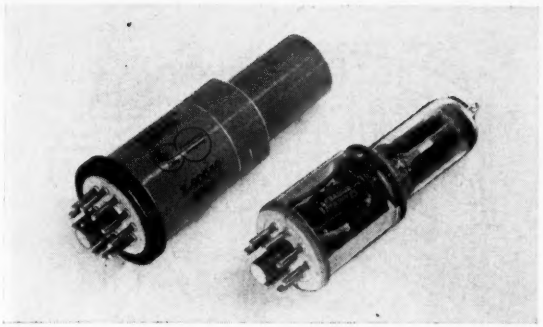


Fig. 5-1. Typical plug-in-type unit circuit for use in digital equipments. This unit uses conventional wiring technique. (Photo courtesy EECO Production Co., Santa Ana, Calif.)

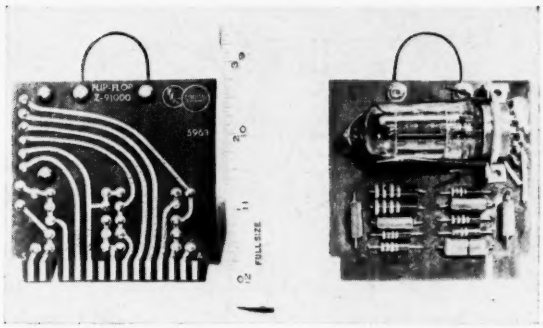


Fig. 5-2. Plug-in-type unit circuit using newer etched-circuit technique. (Photo courtesy EECO Production Co., Santa Ana, Calif.)

Basic Circuits used in DIGITAL AUTOMATION

The basic circuits used in digital automation include the amplifier, cathode follower, oscillator, free-running multivibrator, flip-flop, univibrator, blocking oscillator, phantastron, gating circuits, squaring circuit, clamp, and scaling circuit. Each is described, as is diode and glow-tube coupling for 2-state signals. This is the fifth in this important series on digital techniques.

MARTIN L. KLEIN
FRANK K. WILLIAMS
HARRY C. MORGAN

VACUUM-TUBE CIRCUITS will be used in this discussion of the basic circuits used in digital equipments because most engineers are familiar with the principles and operation of basic vacuum-tube circuits. The less familiar transistor, magnetic element, electrostatic element, etc., could also be used to perform almost all of the same functions to be described, with certain advantages in particular applications. However, the basic functions remain the same, and the vacuum-tube circuits to be described will illustrate these basic functions.

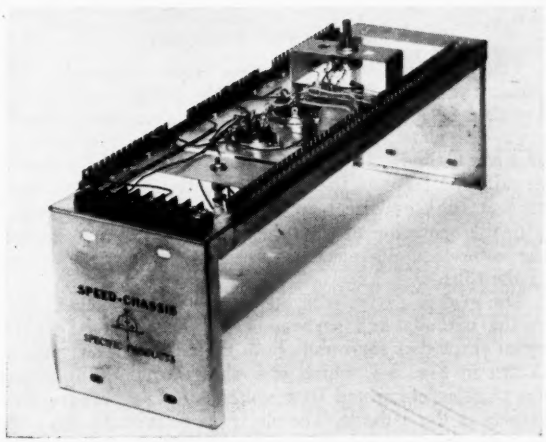
Although the number of individual circuits in use is in the order of thousands, most of these, fortunately, are variations of a few basic circuits, which will be described.

Almost all modern digital equipments use "plug-in" unitized construction because such construction saves time and money. The systems engineer can use plug-in units to reduce design time; construction of a few units can be done in short times; finished equipments are less cluttered; repair and maintenance are simplified. Fig. 5-1 shows the construction of a typical plug-in unit using conventional parts and wiring; Fig. 5-2 shows a newer etched-circuit technique.

Construction of experimental systems can be speeded also by use of special chassis designed for flexibility in prototype and design work. Fig. 5-3 shows one type of chassis which permits rapid construction of experimental circuits.

The circuits used in digital equipments include the amplifier (ac and dc), cathode follower, pulse amplifier, sine-wave oscillator, free-running multivibrator, flip-flop, one-shot multivibrator, blocking oscillator, phantastron, pentagrid gate, gate circuit, squaring circuit, clamp, and

Fig. 5-3. Chassis designed for rapid assembly of experimental circuits. (Photo courtesy Specific Products, Sherman Oaks, Calif.)



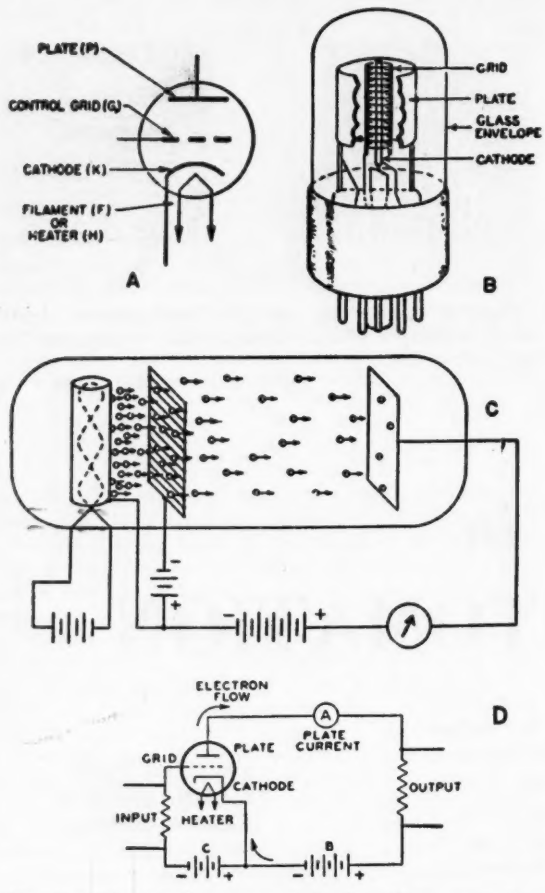


Fig. 5-4. The triode vacuum tube has three operating electrodes—plate, grid, and cathode. Heater serves only to heat cathode. When tube is connected with proper operating voltages and load, grid voltage controls the plate current.

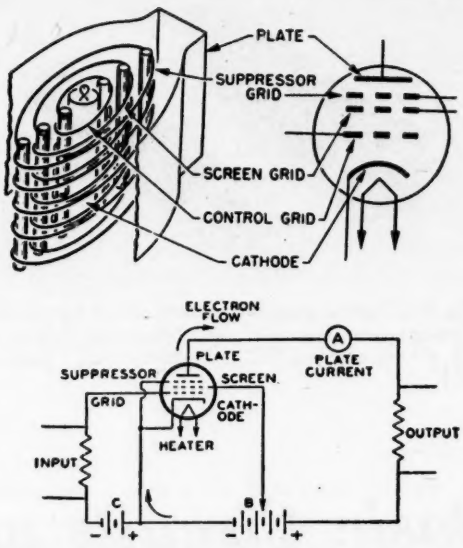


Fig. 5-5. The pentode amplifier uses two additional grids (screen grid and suppressor grid) to increase gain and to reduce the plate-to-grid interelectrode capacitance.

scaling circuit. Each of these basic circuits will be described, after a brief introduction to the triode and pentode vacuum tube.

Triodes and Pentodes

Triodes and pentodes are the most commonly used vacuum tubes in digital circuits. Fig. 5-4 shows a triode, so called because it has three essential elements—cathode, grid, and plate. The heater, or filament, serves only to heat the cathode. This heating method is used because it permits the cathode to be heated with either alternating current (ac) or direct current (dc) without interfering with the operation of the tube in any way. When heated, the cathode emits electrons into the evacuated volume of the tube.

The grid is a wire with open spaces. It is located close to the cathode and surrounds it. The plate is a solid metal sheet that surrounds both the cathode and grid, as shown in Fig. 5-4, which also shows what occurs when the plate is connected to a voltage that is positive with respect to the cathode. The electrons emitted by the cathode flow through the grid to the plate, forming a plate current. This current returns to the cathode through a load (the output resistor in Fig. 5-4) and the B battery.

As the grid is close to the cathode, it can control the flow of electrons from the cathode to the plate. The grid is maintained at a voltage that is slightly negative with respect to the cathode so that little or no plate current flows. However, when an input signal is applied to the grid (between grid and cathode) this signal controls the plate current faithfully—that is, a rise in grid voltage causes a proportional rise in plate current.

Let us suppose that a 1-volt change in grid voltage (the input signal in Fig. 5-4) causes a 1-milliampere change in plate current. If the output load resistor is 10,000 ohms, this 1-ma *change* in plate current will cause a 10-volt *decrease* in plate voltage. Note that a 1-volt increase in grid voltage causes a 10-volt decrease in plate voltage. This is why the tube is called an amplifier; the input signal is amplified 10 times in this case. Note also that phase inversion occurred—that is, the output signal is 180 degrees out of phase with respect to the input signal.

The triode has two disadvantages—relatively high interelectrode capacitance and low amplification. These disadvantages are overcome by using two other elements in the tube, a screen grid and a suppressor grid. The tube with five elements is called a pentode (Fig. 5-5). These added elements reduce the interelectrode capacitance because they effectively result in several capacitances in series, whose net capacitance is less than the original. They increase the over-all gain because they eliminate the effect of plate-potential change on gain. For example, in the triode discussed previously, a plus 1-volt grid change produced a minus 10-volt plate change. This decrease in plate voltage reduces the gain of the triode stage. In the pentode, however, the high positive voltage on the screen grid maintains the gain of the stage by making the plate current relatively independent of plate voltage.

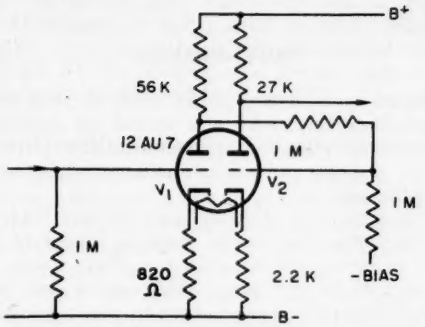


Fig. 5-6. Two-stage d-c amplifier features d-c coupling between stages—that is, amplified signal at plate of first stage is coupled to second stage (for further amplification) through a resistor. Disadvantage is that the resistor coupling serves as a voltage divider that cuts the gain in half.

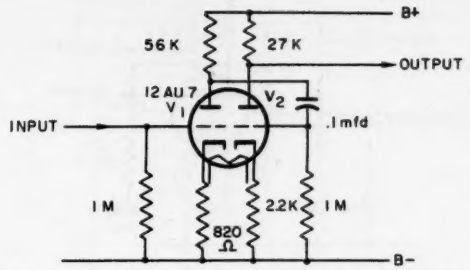


Fig. 5-7. Two-stage a-c amplifier uses resistance-capacitance coupling between the two stages, thus eliminating the voltage-dividing direct coupling of Fig. 5-6.

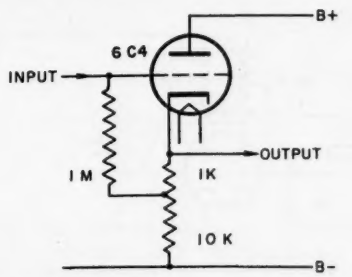


Fig. 5-8. Cathode follower delivers output signal at cathode, rather than at plate as in conventional amplifiers. This gives the circuit its two important characteristics —high input impedance and low output impedance.

There are other types of vacuum tubes, such as *beam power pentodes* (with specially designed elements to produce large currents), *tetrodes* (which do not have a suppressor grid), etc. However, the triode and pentode are used most often in the basic circuits in digital equipments, some of which will now be discussed.

D-C Amplifier

The function of an amplifier is to increase the amplitude of an electrical signal to a desired level. Fig. 5-6 shows a typical 2-stage d-c amplifier, so called because it can accommodate signals of zero frequency (dc). The input signal is applied to the first grid; an amplified but inverted signal appears at the first plate. This signal is coupled to the second grid through a resistor, which is required only because it is part of a voltage divider that applies the proper operating voltage for the second grid. A further amplified signal appears at the output plate. The output signal has been changed in polarity twice, and thus appears at the output in the same phase as the input. That is, the output signal is exactly like the input signal in every respect (except amplitude).

A disadvantage of this d-c amplifier is that the voltage divider between the plate of the first stage and the grid of the second reduces the signal by a factor of 2, and cuts the gain of the amplifier in half. This is not true of the a-c amplifier discussed next.

A-C Amplifier

Fig. 5-7 shows a 2-stage a-c amplifier. The basic difference between this circuit and that of Fig. 5-6 is that the signal is coupled from the plate of the first stage to the grid of the second via a capacitor. The capacitor is chosen to have low reactance at the frequency of the signal to be amplified, and hence acts like a short circuit to the a-c signal, coupling the a-c signal in its entirety from the plate to the grid. However, the capacitor acts like an open circuit to direct current, which blocks the high d-c plate potential of the first plate from the grid of the output stage. Hence this circuit cannot amplify a d-c signal, but has twice the gain of the previous circuit for a-c signals of a given frequency range.

Cathode Follower

The cathode follower is a circuit in which the signal is taken from the cathode, rather than from the plate as in the conventional amplifier. This gives the cathode follower two unique characteristics of great importance—high input impedance and low output impedance. A typical cathode-follower stage is shown in Fig. 5-8.

A positive signal applied to the grid causes an increase in plate current. This current causes a positive signal to appear across the cathode resistors, which signal is almost (but not quite) equal to the input signal. Note that the cathode signal could never exceed the grid signal because this would reduce the plate current (a positive cathode voltage is equivalent to a negative grid voltage) —and the controlling input signal calls for an increase in plate current when it is positive. Hence, the cathode "follows" the grid almost exactly.

This gives the tube its unique characteristics. As the grid and cathode change potential in synchronism, there is little grid-to-cathode *change* in potential, and hence little added change in current flow between grid and cathode. This is the same as saying that the input impedance is very high, as almost no current is required from the source providing the input signal.

The full gain of the tube is used in making the cathode follow the grid. Hence relatively large currents can be taken from the output without reducing the gain of the stage. This is the same as saying that the circuit has low output impedance.

Note that although the circuit has high power gain (provides high output current), it has a voltage gain that

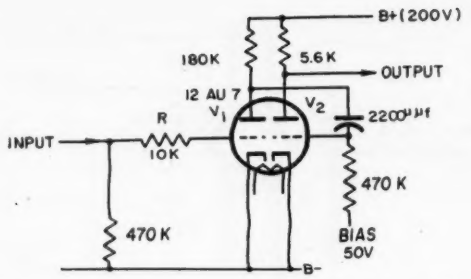


Fig. 5-9. Pulse amplifier uses stages that are fully conducting and nonconducting so that large pulse signals can be accommodated and output pulses will have steep sides.

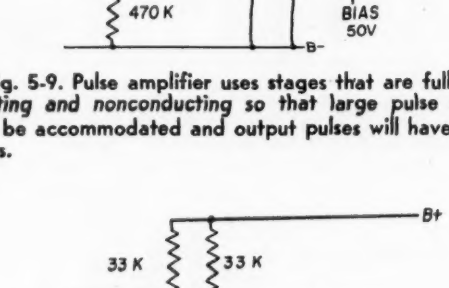


Fig. 5-10. Free-running multivibrator has no stable equilibrium condition, and alternately flips and flops between its two operating conditions—one tube on and one tube off. Output is a chain of pulses, and may be taken from either plate.

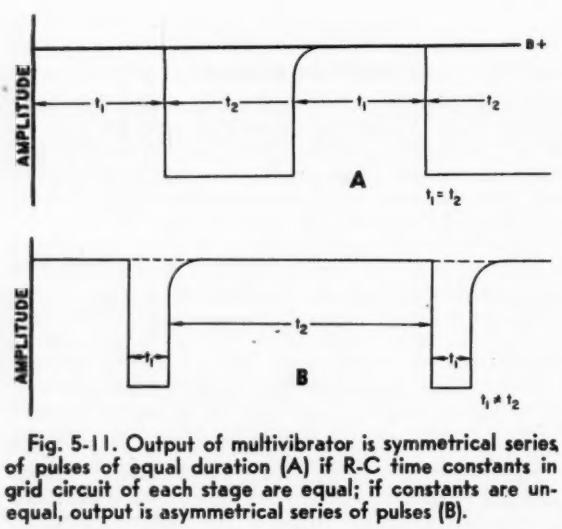


Fig. 5-11. Output of multivibrator is symmetrical series of pulses of equal duration (A) if R-C time constants in grid circuit of each stage are equal; if constants are unequal, output is asymmetrical series of pulses (B).

is less than unity (usually about 0.9). Note also that the output signal is in phase with the input signal; there is no phase inversion in a cathode follower.

The cathode follower is used to take signals from high-impedance sources (which cannot provide any current) and deliver them to low-impedance loads (which require current for their operation). A typical example is in operating a recorder or indicator movement.

Pulse Amplifier

In digital equipments, pulses must be amplified. A pulse amplifier (Fig. 5-9) is a special a-c amplifier designed to accept pulses or square waves. It requires high-frequency response in order to accommodate the steep sides of the signals.

Note that the first stage operates without bias and is conducting; that the second stage is biased to cutoff. Hence a negative pulse is required to obtain a pulse signal at the plate of the first stage. This positive pulse is large enough to cause the second stage to conduct, causing a large negative pulse at the output. In the circuit shown in Fig. 5-9, the input pulse must be 30-volts negative (minimum) to produce an 85-volt negative pulse at the output. These large signals are used because the stages are driven from full cut-off to full conduction, resulting in well-shaped output pulses—that is, pulses having steep sides and flat tops and bottoms.

Astable (Free-Running) Multivibrator

A source of periodically occurring pulses often is needed in digital equipments. The free-running multivibrator (Fig. 5-10) produces such a train of pulses.

This circuit is called also an astable multivibrator because it has two operating conditions, and alternately flips from one to the other without remaining stable in either condition. These conditions are (1) stage 1 conducting while stage 2 is nonconducting and (2) stage 2 conducting while stage 1 is nonconducting. As either stage flips from full conducting to full nonconducting, a square-wave pulse can be obtained at either plate.

The action of the circuit is as follows: Assume a minute *positive* random noise pulse at the grid of stage 1 (such noise pulses always exist). This causes a larger *negative* pulse at the grid of plate 1. This negative signal is coupled to the grid of the second stage, which produces a still larger *positive* signal at the plate of stage 2. This large positive signal is fed back to the input grid at which the small positive noise signal was the initial signal.

Note that a small positive noise signal causes a large positive signal to be fed back into the same grid. This *regenerative* action quickly causes the first stage to become fully conducting and the second stage to be nonconducting. As one stage is fully on and the other fully off, they are said to be saturated, and the plate potentials no longer change—but only for a short interval.

The regenerative action that caused the tubes to be saturated also caused the coupling capacitors to be charged to unusual potentials. Hence, when the plate potentials reach their maximum possible potential (high or low), these capacitors start to discharge their abnormal charge, and plate current again starts to change. As soon as a change in plate current occurs, the same regenerative action occurs in reverse—the "on" tube is driven quickly to cutoff; the "off" tube becomes fully conducting. This alternating action occurs at a frequency determined by the RC time-constants in the grid circuits of the two stages, which constants determine the time in which the coupling capacitors can discharge to start a new cycle.

When the two time constants (R1-C1 and R2-C2) are equal, the signal at the plate of either tube is a series of symmetrical pulses of equal duration, as shown in Fig. 5-11, A. When the time constants are unequal, the output is an asymmetrical wave, as shown in Fig. 5-11, B.

Sine-Wave Oscillator

If a resonant L-C tank is connected between the plates of a multivibrator, as in Fig. 5-12, the tank oscillates and "smooths" the square wave into a sinusoidal waveform (Fig. 5-12, B). The frequency of the sine wave is determined mainly by the value of L and C.

Bistable (Flip-Flop) Multivibrator

Another important variation of the multivibrator is the bistable multivibrator or flip-flop (Fig. 5-13). Note that this circuit is much the same as the astable multivibrator of Fig. 5-10, except that two extra resistors provide direct coupling between the plates and grids of the two stages. These resistors cause the stages to have two stable conditions (unlike the astable multivibrator which kept changing state and had no stable condition).

Note that when stage 1 is fully nonconducting, its plate voltage is high. This high d-c voltage is coupled to grid of stage 2, causing it to be fully conducting. As all voltages are d-c, the two stages will remain in this condition until a strong negative pulse is fed into the grid of the conducting stage. This causes that stage to cut off and the other stage to conduct because of the same regenerative action as occurs in the multivibrator. The two stages will remain in this condition until another large negative pulse is delivered to the grid of the conducting stage.

If the negative triggering pulses are fed to both grids, the circuit will flip and then flop between its two equilibrium conditions. Note that if the output is taken from one plate only, the output will be a negative pulse on the first input, a positive pulse on the second input pulse, and another negative pulse on the third input pulse. As two negative pulses are required for each negative pulse at the output, the circuit can be (and is) used as a frequency divider, or a count-by-two circuit.

Monostable (One-Shot) Multivibrator

Still another variation of the multivibrator is the monostable multivibrator, which is also called a *one-shot multivibrator* or *univibrator* (Fig. 5-14). The first stage (V1) is always conducting in its equilibrium condition because its grid is kept positive by a resistor connected to B+. The plate of the second stage is coupled to the grid of the first stage, but (unlike the conventional multivibrator) the plate of the first stage is not coupled to the grid of the second stage.

If a strong negative pulse is applied to the grid of V1, the plate current in V1 is reduced, causing a negative signal at the common cathode. This negative signal at the cathode of V2 causes an amplified negative signal at the plate of V2, which is coupled back to the grid of V1, causing it to become rapidly nonconducting. As V1 has been cut off, a positive pulse appears at the plate of V1.

However, capacitor C now charges to B+ through resistor R, and V1 starts conducting after an interval determined by the time required to charge C through R. As soon as plate current begins to flow in V1, the same regenerative action causes V1 to become rapidly conducting, at which time the positive potential at the plate of V1 drops to its normal value. Hence a positive pulse has been obtained at the plate of V1 by the triggering action of a negative pulse at the grid of V1. The same action occurs if a positive pulse is applied to the grid of V2. The circuit always returns to its stable condition after being triggered.

Another variation of the monostable multivibrator is shown in Fig. 5-15. Here V2 is always nonconducting in its stable condition because of the bias resistor, and V1 conducts in its stable state. A positive pulse at the grid of

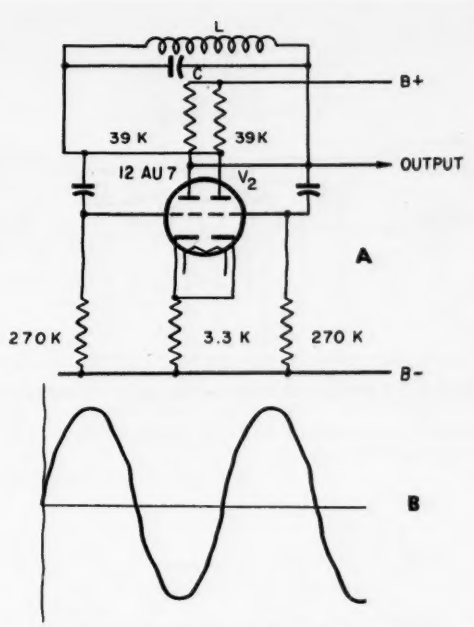


Fig. 5-12. This sine-wave oscillator is essentially a multivibrator with resonant tuned tank connected across the plates. Tank smooths waveform into sine wave, as shown in B.

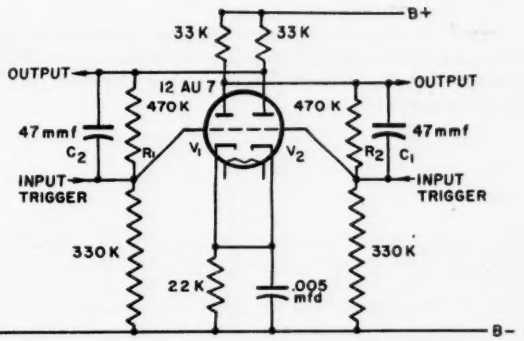


Fig. 5-13. Bistable (flip-flop) multivibrator can remain in either of two stable conditions—one tube on and other off. Trigger causes tubes to reverse condition. Basic use is in frequency division and counting by 2.

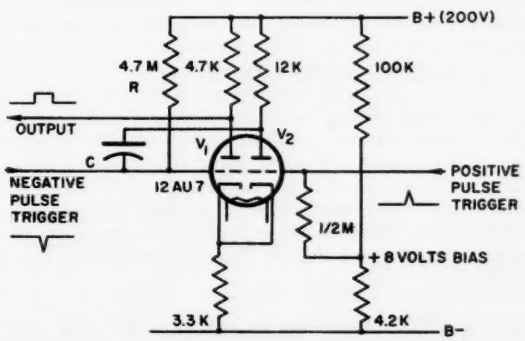


Fig. 5-14. Monostable multivibrator has only one stable operating condition because of d-c bias of one stage, and returns to this state after being triggered.

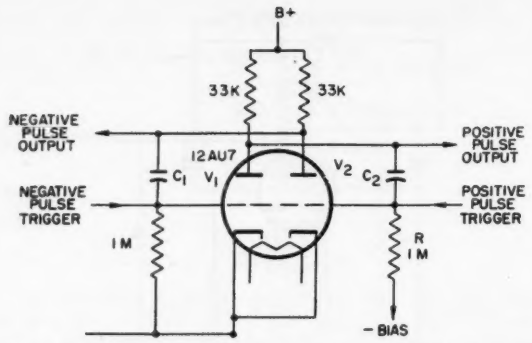


Fig. 5-15. Another variation of the monostable vibrator.

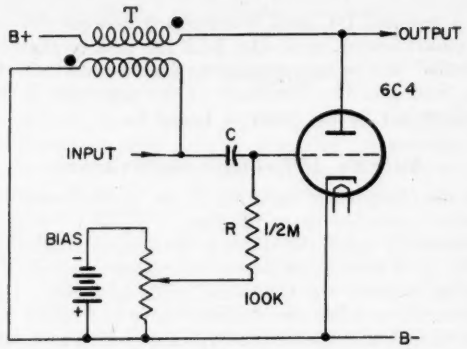


Fig. 5-17. Blocking oscillator is another circuit that produces a train of pulses. Pulses can be of shorter duration than those from multivibrator.

Fig. 5-16. Use of a diode and square-wave pulse input (from univibrator) to develop a spike-pulse output that is delayed for an interval equal to the duration of the square-wave pulse.

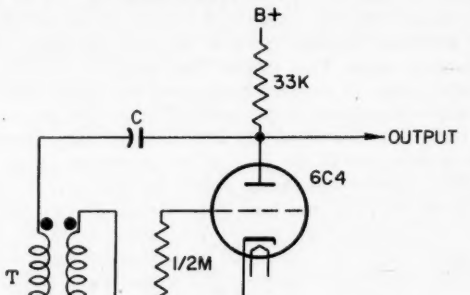


Fig. 5-18. Another variation of the blocking oscillator.

V2 (or a negative pulse at the grid of V1) causes regenerative action that cuts off V1 and turns on V2; however, this condition lasts only until the capacitors leak off their signals and the tubes return to their equilibrium condition. The length of the output pulse thus depends on the size of the capacitors (1 and 2).

Fig. 5-16 shows an interesting application of the monostable multivibrator—the development of a delayed pulse. Each input trigger to the monostable multivibrator causes a negative-going pulse output from the plate of V2 (as shown in both Fig. 5-15 and 5-16); the duration of this pulse is established by the R-C constants of the multivibrator circuit. If this pulse is coupled to a diode as shown, the diode conducts only when the voltage changes in a positive direction—which occurs only at the *end* of the plate-signal pulse. Hence the output signal (a sharp spike) occurs across the output resistor at the end of the input pulse, when it is positive going. The result is an output spike that occurs after the input trigger by an interval equal to the duration of the pulse produced by the multivibrator. This circuit is thus known as a delayed-pulse circuit. The amount of delay is established by the univibrator.

Blocking Oscillator

Another circuit that produces a train of pulses is the blocking oscillator (Fig. 5-17), which uses only a single tube and a transformer (rather than the two tubes of the multivibrator). The blocking oscillator can produce pulses of shorter duration than the multivibrator because the inductive reactance of the transformer speeds the signal build-up, resulting in shorter pulses.

The transformer is connected so that regeneration occurs—that is, a negative grid signal (such as a minute noise impulse) causes a positive plate signal that induces a larger negative signal at the grid. This action rapidly causes the stage to be driven far into cutoff. After a period of time required for capacitor C to discharge its accumulated negative charge through resistor R, a small plate current begins to flow and the opposite action occurs—that is, a small drop in plate voltage causes a positive signal to be induced on the grid, which in turn causes a still larger negative signal at the plate. This action causes the tube to become rapidly fully conducting. The pulse repetition rate of this circuit depends on the time constant of the resistor R and capacitor C.

The circuit in Fig. 5-17 is free running (astable) if the bias potentiometer is adjusted so that the bias is very low (near zero); if the bias is increased to the point where the tube is normally nonconducting, the circuit becomes a monostable (one shot) multivibrator requiring a positive triggering pulse at the grid.

Fig. 5-18 shows a cathode-coupled version of the astable blocking oscillator.

Miller Integrator

The Miller Integrator (Fig. 5-19) is a circuit used to obtain a slowly rising or falling sawtooth waveform of

good linearity. In this circuit the supressor grid (g3) is maintained at a large negative potential so that the tube current goes to the screen rather than to the plate. The control grid (g1) is returned through a resistor of high resistance to the B plus.

When a positive step or square-wave voltage is applied to the suppressor grid (g3), the plate receives its normal current, and the plate potential starts to fall. However, it cannot fall rapidly because the plate is coupled to the grid via a capacitor (C1), and a rapid signal change would be transmitted to the grid, which would cause plate current to decrease and plate potential to rise. Hence only a slow linear fall in plate potential results. At the end of the gating input pulse, the plate potential rises exponentially to B voltage.

The circuit is "gated" by the square-wave input—that is, it is turned on for the duration of the positive excursions of the input waveform.

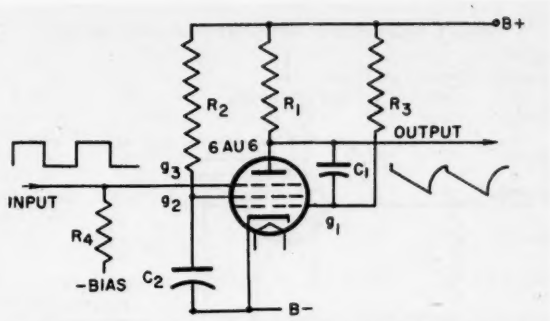


Fig. 5-19. Gated Miller integrator circuit. Negative suppressor grid repels plate current to screen until positive gating signal appears at input. Plate current then flows to plate, causing plate potential to decrease. However, fall of plate voltage must be slow because of the capacitor coupling the plate to the grid.

Phantastron

The phantastron circuit (Fig. 5-20) is similar to the gated Miller except that the supressor is not connected to a negative potential and, therefore, only a trigger is required to initiate the "rundown" of the plate (rather than the gate required of the Miller integrator).

Before the trigger is applied, the tube current flows to the screen, and the plate is at a high potential (near that of the B supply). When the negative trigger is applied to the suppressor, plate current flows to the plate, which, however, cannot exhibit a rapid drop in potential because of the capacitor coupling of the plate to the grid. Hence a slow linear rundown (the diode increases the linearity of the rundown) in plate potential occurs until "bottoming" occurs. This happens when the grid voltage stops being influenced by the dropping plate voltage, and begins to rise. When this happens, the cathode voltage rises and, when it rises above the supressor voltage, the current starts flowing to the screen again, and the grid and plate voltages go still higher. The plate then rises exponentially to its high value and remains there until another negative trigger starts another rundown.

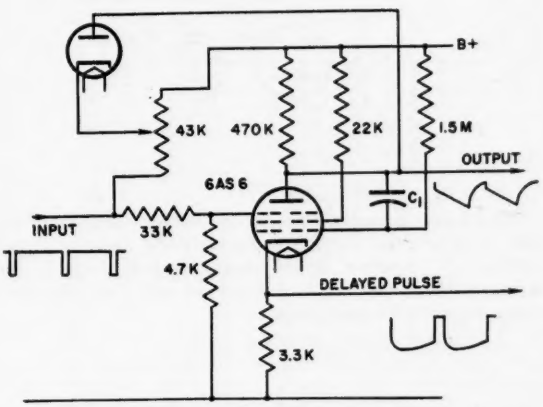


Fig. 5-20. Phantastron is similar to Miller integrator, but requires only trigger (rather than a wide gate) to initiate "rundown" of plate voltage.

Pentagrid Gate

A coincidence circuit is a circuit which produces an output pulse only when *two* pulses are received simultaneously, or coincidentally. This is also called an "*and*" circuit.

In the pentagrid gate shown in Fig. 5-21, the control grid (g1) is biased to −50 v; the screen grid (g3) is biased to −20 v. No current can flow to the plate until positive signals (50-v positive signal to the control grid and a 20-v positive signal to grid 3) are applied simultaneously. When both appear simultaneously, plate current flows, and an output pulse appears at the plate.

Duo-Diode Gate Circuit

If a gate circuit is required which operates on coincidence of a negative and a positive pulse, then a gate circuit such as is shown in Fig. 5-22 is used. The left triode is normally conducting, while the right triode is normally non-conducting (due to a 100-v negative bias). When a 90-volt positive pulse is applied to the right-hand grid, and a 20-volt negative pulse is applied to the left-hand grid, a negative pulse output pulse is obtained. Unless these two pulses are applied simultaneously, no output results.

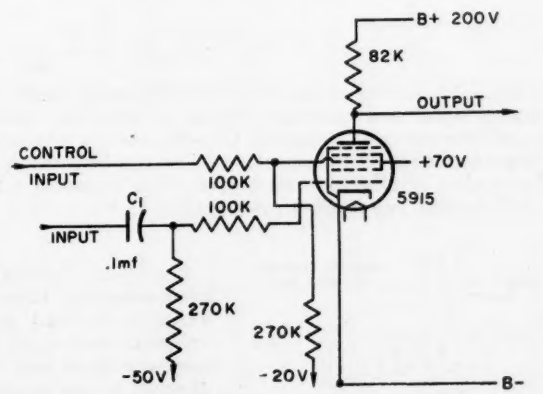


Fig. 5-21. Pentagrid gate circuit requires two input pulses to appear in coincidence before output pulse appears at plate. In this circuit a 50-volt positive signal at the grid, and a 20-volt positive signal at the plate, are required.

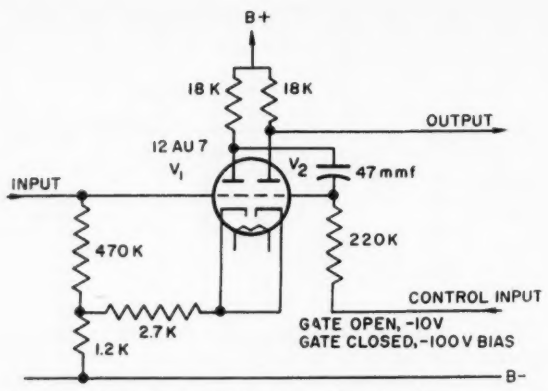


Fig. 5-22. Gate circuit that requires simultaneous positive (to V2) and negative (to V1) input pulses before an output pulse is formed.

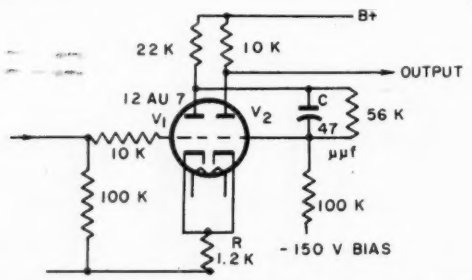


Fig. 5-23. Squaring circuit is 2-stage d-c amplifier with regenerative feedback via cathode resistor. Small positive or negative signal causes output stage to be quickly driven full off and then full on, resulting in a pulse output with sharp sides.

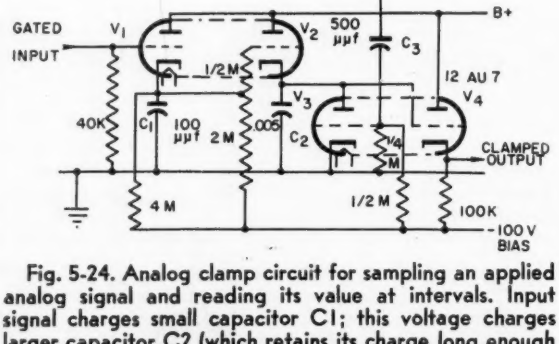


Fig. 5-24. Analog clamp circuit for sampling an applied analog signal and reading its value at intervals. Input signal charges small capacitor C1; this voltage charges larger capacitor C2 (which retains its charge long enough for reading or other purposes), after which capacitor C2 is discharged by recycling pulse applied to V3.

Fig. 5-25. Typical beam-switching tube. Beam is formed by crossed electric and magnetic fields and is directed to one target plate at a time. Input pulses cause beam to switch from one target to the next. (Photo courtesy Burroughs Corp.)

Squaring Circuit

It is frequently required that a sine or complex waveform be converted into a square wave needed to drive a bistable multivibrator or similar circuit. Fig. 5-23 shows such a circuit. This is a d-c (direct-coupled) two-stage amplifier such as is shown in Fig. 5-6, with the addition of the common cathode resistor R and the coupling capacitor C. Capacitor C couples fast-changing voltages (such as the portion of a sine wave going through zero potential), thus steepening the rise or fall of the square wave. When the input grid goes positive, its plate goes negative. Capacitor C couples this negative signal to the second grid, which results in a negative signal at the common cathode. When the cathode of the first stage becomes more negative, this results in a still larger negative signal at the plate. This regenerative action quickly cuts off the right triode. In a similar fashion, a negative-going signal or sine wave on the input grid quickly causes V2 to draw its maximum current. This double action results in a square wave output if the input signal to the first grid is at least 27 volts peak to peak.

Analog Clamp or Holding Circuit

This important circuit is used in analog-to-digital converters to maintain a fixed analog sample voltage until conversion to code has been made. This obviates the interpretation difficulties which would occur if coding were completed at different time intervals.

Fig. 5-24 illustrates a circuit which is frequently called a *recycling clamp*. This circuit operates as follows: A brief sample of an analog voltage is gated to the grid of V1 for a 5- or 10-microsecond interval by a gating circuit. Due to the fact that the cathode of V1 is returned to a negative bias voltage, V1 has a low plate resistance, which allows capacitor C1 to be charged in a few microseconds to a potential which is directly proportional to the gated analog sample voltage. The charge on C1 remains long enough to charge C2 to a potential which is also directly proportional to the gated analog sample voltage. As C2 is five hundred times the capacity of C1, it will hold the potential (which represents the analog input sample) for ten or more milliseconds without significant loss of charge leaking off due to stray resistance leakage paths. The value of the charge on C2 is transmitted to following circuitry via cathode follower V4. After the required interval of time has passed, and a new analog sample voltage is required to be clamped, a positive recycling pulse (50 volts or more) is applied to the grid of V3, which allows V3 to conduct and discharge or "dump" the charge on C2. Normally, V3 is held cut off by the large negative bias voltage applied to the grid.

Special Scaling or Switching Tubes

Table 5-1 lists the characteristics of some of the recently developed scaling and switching tubes. Except for the Burroughs tubes (Fig. 5-25) all of the listed tubes have some means for visual indication of the particular electrode position active at a given instant. This may be a spot of light from a fluorescent screen or a gas glow. Electrodes or masks sometimes are arranged to display the actual number of the active electrode.

In general, the operation of these special tubes may be described as follows: A number of anode electrodes (usually ten so as to conform to the decimal system) are symmetrically disposed about a central cathode. The current or beam in the tube is made to strike one anode at a time, and a visual or electrical signal indicates the progression state of the switched current or beam. There are one or

more switching grids or elements for each output plate, which, when a switching pulse is applied, will cause the electrical current to the active plate to change to the next output plate or electrode. Thus a succession of pulses to the switching grids will cause the output current to be progressively switched to each plate in succession.

Diode and Glow-Tube Coupling

In addition to conventional coupling means (such as resistance-capacitance and transformer coupling), digital automation circuits often use diode and glow-tube coupling. This coupling technique is used often when a two-state (binary) signal must be transferred to a succeeding stage.

Fig. 5-26 illustrates how a crystal diode can be used to transfer a signal indicating when the potential of the cathode of V1 is above the potential of the battery. When the potential of the cathode is above the potential of the battery, the diode conducts and a positive output signal appears across R2. When the cathode potential is below that of the battery, the diode is a high resistance and an insignificant signal appears across R2.

Vacuum diodes are sometimes used instead of crystal diodes in circuits which benefit from their characteristics.

Fig. 5-27 shows a convenient method of coupling a two-state plate potential (such as is available from a bistable multivibrator) to succeeding circuitry. A small inexpensive neon glow lamp (NE-2) couples the plate to the output resistor R3. When V1 is conducting, the potential of its plate above B— is less than the voltage required to maintain the glow discharge through the NE-2, and the tube is "off"; no signal appears across R3 under these conditions. However, when tube V1 is non-conducting, the plate potential is high enough (and resistor R1 is of sufficiently low resistance) to ionize the gas in the NE-2, and a positive voltage output level appears across R3. In order to operate from plate supplies of more than 100 volts, two or more NE-2's in series are used.

Glow Lamps as Matrix Elements

Neon glow lamps can be used advantageously in some circuits in place of crystal diodes. In most medium- and high-level matrix switching circuits, NE-2 glow lamps can be used as reliable and inexpensive matrix elements; in matrix work, where a 0 to 1 level is to be indicated, NE-2's are extremely useful. An added advantage is that the operator can observe the matrix operation visually for state or malfunction.

Fig. 5-28 is a simple NE-2 matrix which is a neon-glow-lamp version of the matrix discussed in Chapter 3 and shown in Fig. 3-2. This matrix is the same as Fig. 3-2 except that glow lamps are used instead of diodes.

When both switches are in the zero position, as shown, NE-2's *c*, *g*, *f*, and *h* are grounded by the switches, which means that they will ionize and conduct. Either *g* or *h* will conduct, depending on which ionizes first; and since they are both on line 3 it does not matter if one or the other is the one which ionizes. Note that lines 1, 2, and 3 are now each about 67 volts above ground (the voltage drop across the glow discharge). Line 0, however, is still at the 90-volt battery potential.

Power Supplies

Although some electronic circuits are not sensitive to supply voltage, others are critical, especially where direct-current coupling methods must be used. Therefore, regulated power supplies to accurately maintain fixed supply voltages are usually used in digital automation circuits.

Table 5-1.—Scaling or Switching Tubes

Tube	Type	Pulse Input	Amplitude (Volts)	Length (usec)	Max. Frequency (Cps)
Dekatron[1,2] GC10B	Gas Filled	Double; 120° out of Phase	130	30-80	5,000
Dekatron GC10D	Gas Filled	Single; triangular	130	25	16,000
Nomotron G 10/241	Gas Filled	Single; square	150	12	60,000
Philips[3] E I T	Vacuum	Triangular	10	9-10	100,000
Burroughs[4] MO-10	Vacuum	Single	12-15	0.1	1,000,000
MO-10R	Vacuum	Single	12-15	0.1	5,200,000

[1]J. C. Baker and G. G. Eicholz, **Nucleonics**, Vol. 12, No. 4
[2]Atomic Instrument Company. (The Sylvania 6476 is similar.)
[3]North American Philips Co., also Amperex Electronic Corp.
[4]Burroughs Corp.

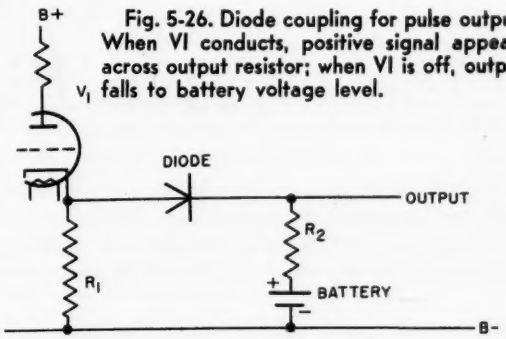


Fig. 5-26. Diode coupling for pulse output. When V1 conducts, positive signal appears across output resistor; when V1 is off, output falls to battery voltage level.

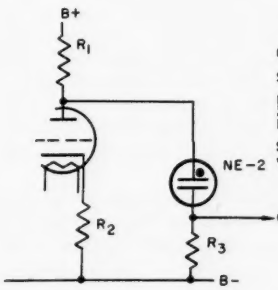


Fig. 5-27. Glow tube also can be used for coupling two-state signals. When V1 is off, plate potential is high, NE-2 ionizes, and positive output signal appears at output. When V1 is conducting, plate potential falls, NE-2 deionizes, and output falls to level of B—.

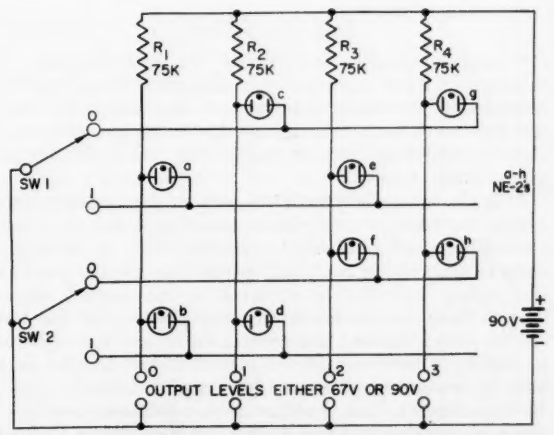


Fig. 5-28. Basic 4-decision matrix using NE-2's rather than diodes. Voltage level at each output can be either 67 or 90 v, depending on position of switches.

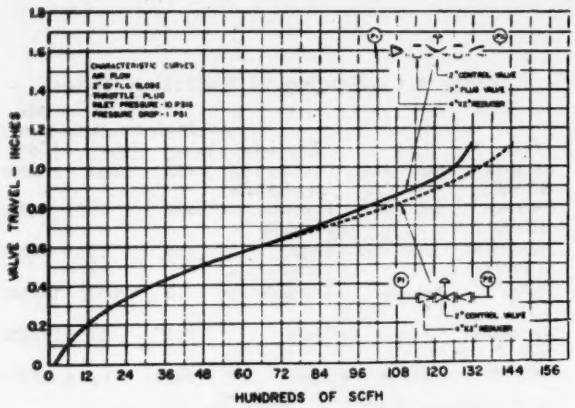


Fig. 1. 2"-control-valve characteristic curves—with and without plug cocks—low pressure drop.

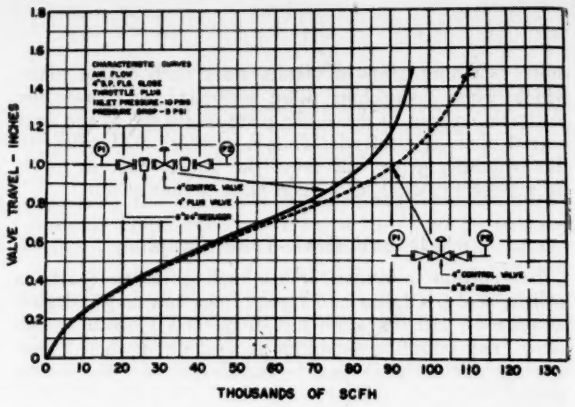


Fig. 2. 4"-control-valve characteristic curves—with and without plug cocks—low pressure drop.

OSI-

Valve Piping Effects

Control valves can exhibit changes in characteristic and reduction in capacity due to piping configurations adjacent to the control valves. This article presents test results indicating the order of magnitude and nature of changes which can be expected in a few of the more common control-valve manifolds.

G. F. BROCKETT
Fisher Governor Co.

W. J. L. KENNEDY
Stone & Webster Engr. Corp.

CONTROL valves oftentimes are installed with little thought as to the effect which piping arrangement immediately adjacent to the valve will have on its performance. Process-control engineers carefully size each valve and specify suitable plug characteristics. The actual installation layout is then turned over to piping designers, who in general give little thought to the control functions of the valve. It is also common practice to neglect an allowance for the pressure drop through the block valves and attendant piping.

It is a regrettable fact that in many instances the care used in specifying control valves in the engineering stages of a project, and the efforts of manufacturers to provide precise valve characteristics and capacities, are partially nullified by poor installation practices.

Test Conditions

In the test results which follow, the basic capacity of the control valve is plotted for reference. This capacity is measured by taking the pressure drop across the control valve plus the pressure drop due to the two necessary reducers which are located at the inlet and outlet flanges of the control valve.

It is also common practice to include the pressure drop across the entire control-valve manifold under the pressure differential available for control. That is, if 10 psi drop is allowed for control, 2 psi of this may be used in the piping immediately adjacent to the control valve. The authors have adhered to this practice in the test results which follow; the control valve and its adjacent piping have been considered a system and treated as a unit in assigning pressure drop and calculating flow. It seems obvious that a reduction in effective capacity of the control valve will result; the fact that this is obvious does not insure that its effects will be compensated for. If it were not true that many control valves are oversized by duplication of safety factors, this effect would be more commonly noticed.

The first test manifold consisted of a single-ported control valve with a throttle-plug inner valve in a 4-in line with 2-in plug cocks used as block valves and 4-in by 2-in concentric reducers. Pressures were taken at the inlet and outlet of the manifold. Fig. 1 shows a plot of the data taken in test runs using air at 10-psig inlet pressure with a 1-psi pressure drop. The curve on the right represents the valve capacity in a straight 4-in line with 4-in by 2-in reducers on the valve inlet and outlet. The installation of a plug cock reduces the maximum capacity approximately 8½ percent.

Increases in upstream pressure and pressure drop aggravate the situation even more. With the identical piping arrangement and 100 psig air, using maximum pressure drop—the capacity is reduced by 13½ percent. Test results using pressures between these two extremes show a continuous drop in capacity with increasing upstream pressure and pressure drop. The installation of a double-ported control valve in place of the single-ported valve gives very nearly identical results.

Again, using the test arrangement as before, but with water as the fluid, a reduction of about 9 percent in maximum capacity results. This test was run with 100 psig inlet and 5 psi drop. Tests at other pressures and pressure drops, with both single- and double-ported valves, gave similar results.

A second series of tests similar to the foregoing, but substituting 4-in plug valves for the 2-in plug valves, and relocating the reducers was conducted. Under these conditions the manifolding has little effect on the valve capacity and characteristics.

When the pressure conditions were increased to 75 psig and maximum pressure drop, while the maximum capacity was reduced only slightly, the valve characteristic was changed somewhat in the last 40 percent of the

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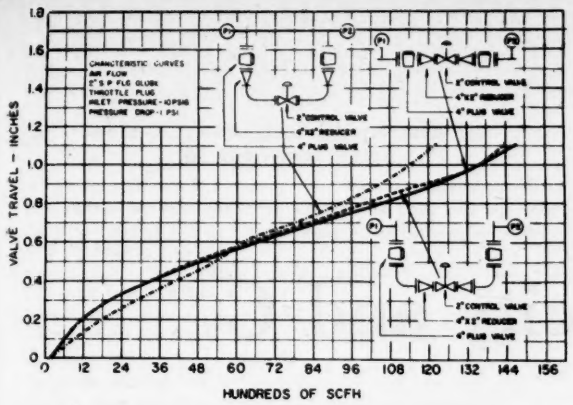

Fig. 3. 2"-control-valve characteristic curves—with elbows before and after concentric reducers—single-ported valve body.

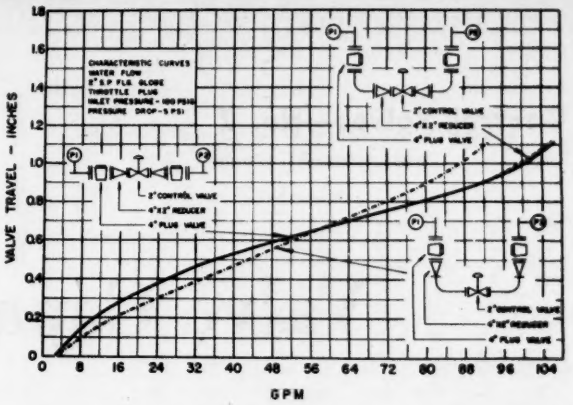

Fig. 4. 2"-control-valve characteristic curves—with elbow before and after concentric reducers—single-ported body—water flow.

stroke. This is in all probability due to the flow pattern introduced by the piping in the single-ported valve body. No such results are indicated by tests using double-ported bodies under the same conditions.

In general, liquid flow through the manifold using line-sized plug valves shows very little change in characteristic or capacity. Double-ported valves having low pressure drops show a 4- or 5-percent decrease in maximum capacity. The effect is negligible when the pressure drop is raised to 5 psi.

In order to check the foregoing results for larger sized valves and lines, similar tests were run using the 8-in line and a 4-in control valve, 4-in block valves and 8-in by 4-in concentric reducers.

Results closely paralleling the results on the 4-in line were obtained. The effects on capacity and characteristic are, however, much larger. Fig. 2, using air at 10 psig and a pressure drop of 5 psi, shows a 13.5-percent capacity reduction and a large change in characteristic during the last third of the stroke. Increasing the pressure to 75 psig and using maximum pressure drop produces the same general curve showing about 21 percent loss of capacity and poor control characteristics during the last third of the stroke. The same results are found if a 4-in double-ported control valve is substituted.

Results using water as the flowing medium at 100-psig inlet pressure and 5-psi pressure drop with a single-ported 4-in valve showed a capacity reduction of slightly over 10 percent. Runs on a double-ported valve at low pressures indicated the same results.

The U-type control-valve manifold (Fig. 3) also was tested extensively. This arrangement is probably the most common configuration in use.

The first series of tests utilized a 2-in control valve in a 4-in line with line-sized plug valves, 4- by 2-in concentric reducers at the valve inlet and 4-in standard-radius elbows. The second series of tests used a 2-in control valve in a 4-in line, 4-in line-sized plug valves, 4- by 2-in concentric reducers, and 2-in standard-radius elbows. The results of both series of tests under the same pressure conditions are plotted on the same axis. The effects of the "tee" fittings (sometimes used in this arrangement) were not included.

The curves in Fig. 3 are the results using 10-psig air at 1-psi pressure drop. It will be noted that the results using the 2-in elbows are much more pronounced than with the 4-in elbows. For the 2-in elbows a 17-percent reduction in capacity is shown; but more important, the valve characteristic is greatly altered through the full range of travel.

Comparison tests with a 2-in double-ported valve were made also. Percentagewise the capacity loss was identical for both the single- and double-ported valves. The characteristic of the double-ported valve, however, remained more nearly constant.

It was in this series of tests that the most interesting results for liquid flows were noticed. Referring to Fig. 4, covering the 2-in single-ported valve, no effect can be seen due to the installation with 4-in elbows. An almost straight-line characteristic is developed when the 2-in elbows are used, and the capacity is reduced by about 12 percent. A double-ported valve, showed similar results in capacity reduction but the characteristic change proved to be unimportant.

Conclusions

While the results of these tests as far as *capacity reduction* is concerned could probably have been predicted, the changes in valve *characteristic* are not predictable.

The reported tests used plug valves; other types of valves and fittings could have been used and the results obtained would then depend upon the flow pattern and pressure loss characteristics through them.

It is common practice to reduce the size of the inlet and outlet blocks, as well as to add elbows in the manifold. It can be expected that this will result in impaired capacity and characteristic.

It is believed that these basic tests indicate several general points:

(1) Arrangements which amount to a nozzle effect into the body of a single-seated valve will alter its characteristic adversely.

(2) Reduction from line size of inlet block valves will affect characteristic and capacity. Thus, a saving in valve cost will require more pumping horsepower for the same flow rate.

(3) If a block and by-pass arrangement must be used around a control valve, the valve is best placed in a straight-through section. Rather tortuous manifolds are sometimes provided for control valves in order to obtain accessibility. Their adverse effect on valve characteristic and capacity should be reviewed.

(4) In gas service, the fact that critical pressure drop is available does not insure that the valve capacity will be unaffected by pressure loss in the manifold.

Great care must be used in applying these results to other types of installations, particularly those involving high pressure drops, viscous flow, and two-phase flow. Control valves sometimes develop discontinuities of great magnitude in characteristic; insufficient care in selecting the piping arrangements around the control valve can magnify these problems greatly.

Valve Capacity and C_v

The C_v technique for valve sizing is becoming standard—yet formulas for flow capacity of a valve are presented in too many different ways at present. This clear résumé of the various formulas for liquid, gas, and steam flow through valves should do much to clarify perspective and establish a more nearly standard—or at least better accepted—type of formulation.

C. S. BEARD
Foster Engineering Company

IN DESCRIBING types of automatic valves, the first interest is in the numerous and ingenious body designs. The physical characteristics of an "ideal valve" (Table 2-1) give the reader a basis for comparison of the various bodies and for determining those that are important for a particular application. In addition to these physical characteristics, there are two important factors that require detailed discussion. These are the *flow capacity* and *flow characteristic* of the valve. This chapter deals with capacity.

Flow Capacity

Flow capacity of a valve is the maximum volume of liquid, gas, or steam that may be put through the valve per unit time with the valve fully open. Flow capacity is thus the maximum flow rate through the valve.

Maximum flow capacity is made up of many factors, including pressure drop across valve, difference in energy level at the valve inlet and outlet, type of fluid flowing, viscosity and gravity of the fluid, etc.

As a Venturi section has the least pressure loss of any engineered obstruction, it would seem that a valve designed with a variable Venturi throat would have the greatest flow capacity. This is true, but the mechanical difficulty and the necessity for obtaining other control characteristics have precluded this approach to valve design.

C_v

Use of the *flow coefficient*, C_v, has offered a standard approach for comparing valves to determine the correct one for a particular service. The flow coefficient of a valve is the volume of water (in gallons) that will flow (per minute) through the valve body with a pressure drop of one psi across the valve when the valve is wide open. Table 2-2 shows the wide variation of C_v for valves of the same size—even supposedly of the same design. C_v-factor usage is based on faith that the manufacturer has run tests on his products so that his published data may be used with confidence. Test data are available for most of the equipment on the market, with the exception of very large valves.

Basic Flow Equation

The entire theory of inferential flow measurement and control is based on the equation

$$Q = K\sqrt{\Delta p} \qquad (1)$$

where Q is the flow rate, Δp is the pressure drop across the orifice or valve, and K is a constant. In orifice metering, the constant K is associated with an *orifice coefficient;* in valve control of flow the constant K is associated with the *valve coefficient* C_v:

$$Q = C_v\sqrt{\Delta p} \qquad (2)$$

The valve size in inches bears an obvious relation to flow capacity, and some may wish to use the basic flow equation to arrive immediately at a valve size, rather than a C_v. This technique seems plausible, and some manufacturers still give the basic flow formula in terms of nominal valve size (d) rather than C_v, as follows:

$$Q = Kd^2\sqrt{\Delta p} \qquad (3)$$

Referring to Table 2-2 it may be seen that manufacturers C and H may have calculated their C_v's from the above equation, using K equal to 10 in the first instance, and 12 in the second.

This practice should be discouraged. The C_v value for a valve should be an experimentally derived figure, and the flow formulas based on C_v, rather than d, should be used in sizing valves.

Specific Flow Equations with C_v

The following basic flow equations make it possible to apply the C_v factor to determine the capacity of a valve when the pressure drop across the valve (and specific gravity, temperature, etc.) are known—or to determine the C_v if the capacity and other factors are known. As

Table 2-1.—Physical Characteristics of the Ideal Valve

1. Minimum hysteresis in port movement creating variable opening.
2. No leakage between operating areas of the body and topworks.
3. Structural design to give desired pressure and temperature ratings without excessive weight.
4. Easy access to parts subject to wear—preferably without removing the body from the line.
5. Design that allows action of valve to be reversed, or allows flow characteristics or capacity to be varied by change in parts.
6. Self cleaning.
7. Indicator showing how far open the valve may be.
8. Positive and complete shut-off for services requiring same.
9. Design so that unbalanced forces do not hinder the proper operation of the valve.

Table 2-2.—C_v of Various-Sized Valves of Various Manufacture.

Valve Size	Manufacturer A	B	C	D	E	F	G	H
1"	—	12	10	16	13	17	12	12
1½"	26	26	25	33	30	39	28	27
2"	45	49	40	56	50	61	48	48
2½"	73	71	63	72	75	98	72	75
3"	104	103	100	115	105	150	100	108
4"	182	168	160	185	170	219	165	192
6"	404	367	360	360	360	500	360	432
8"	705	672	640	700	640	700	640	768

The basic flow equations appear in various forms in different manuals and reference sources, several forms of the equation are given. The following terminology is used, with capital T and P referring to absolute values of temperature and pressure, and lower-case t and p referring to gage values:

Q_L is flow of *liquid* in U.S. gallons/minute

Q_G is flow of *gas* in standard cubic feet/hour (i.e. at 14.7 psia and 60° F)

Q_S is flow of *steam* in pounds/hour

P_1 is inlet pressure in psia (gage pressure plus 14.7)

P_2 is outlet pressure in psia

Δp is pressure drop across valve in psi (not psia or psig). It may be expressed in various equations as either P_1-P_2 or p_1-p_2, where p_1 and p_2 are in psig.

T is absolute Fahrenheit temperature of flowing material (°F plus 460)

G is specific gravity at flowing conditions. For liquid it is referred to water = 1; for gas it is referred to air = 1

V_1 is specific volume of steam at inlet in cu ft/lb = 1/density

V_o is specific volume of steam at outlet in cu ft/lb

X is quality of superheated steam in %.

S is superheat of steam in degrees F.

M is molecular weight of gas.

Distinction must be made at once between critical and noncritical flow of steam or gas (compressible fluids). When the drop across the valve exceeds $P_1/2$, the flow rate no longer follows the basic equation $Q = K\sqrt{\Delta p}$, and other *critical-flow* formulas are used. All gas flow equations containing the term Δp or P_2 apply to flow that is subcritical.

Liquid

$$Q_L = C_v\sqrt{\Delta p/G} \qquad (4)$$

Steam

Dry Saturated Steam

$$Q_s = 3C_v\sqrt{P_2\,\Delta\,p} \qquad (5)$$

$$Q_s = 63.4\ C_v\sqrt{\Delta p/V_o} \qquad (6)$$

$$Q_s = 63.0\ C_v\sqrt{\Delta p/V_1} \qquad (7)$$

The only difference between gas equations (5) and (6) is that the former is in terms of downstream pressure, the latter in terms of specific volume. The only difference between (6) and (7) is that the former is in terms of downstream specific volume, the latter upstream. Equation (6) checks out better than (7) against equation (5) and is therefore recommended by the author.

Dry Saturated Steam—Critical Flow

$$Q_s = 3C_v\ (P_1/2) \qquad (8)$$

Superheat and Moisture Correction

To correct for superheat, divide Qs by $\sqrt{X}$, or by $(1+0.00065S)$.

To correct for moisture, divide Q_S by Quality, where Quality = (1 minus the moisture content in %). For example, if the steam has moisture content of 2%, the Quality = $(1 - 0.02) = 0.98$.

Gas

For gas at or near standard temperature (60°F):

$$Q_G = 61\ C_v\sqrt{P_2\Delta p/G} \qquad (9)$$

Temperature Correction

Gases at temperature far from standard require a temperature-correction factor, which is simply the ratio of

$$\sqrt{T_{60}/T} = \sqrt{(460+60)/(460+t)}$$
$$= \sqrt{520/T}$$
$$= 22.8/\sqrt{T}$$

Thus equation (9) corrected for temperature becomes

$$Q_G = 61\ C_v\sqrt{P_2\Delta p/G}\ \times\ 22.8\sqrt{T}$$
$$= 1390\ C_v\sqrt{P_2\Delta p/GT} \qquad (10)$$

It is of interest to note that the temperature-correction factor $22.8/\sqrt{T}$ changes the result by only 6% at 0°F ($\sqrt{520/460} = 1.06$) and at 130°F ($\sqrt{520/590} = 0.94$). Hence this correction can be ignored for gases between 0 and 130°F if this accuracy is sufficient—and it should be kept in mind that all equations containing C_v are seldom accurate to more than 5% or 10%, because manufacturers establish their C_v factors using different piping configurations and points of pressure measurement.

The gas equations that follow give Q_G in other forms. Although each includes the temperature correction, each can be converted to a form that neglects this correction by dividing the equation by 22.8 and dropping

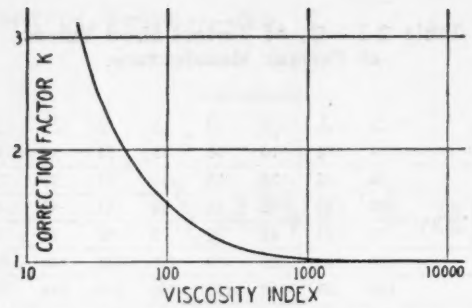

Fig. 2-1. Correction factor for viscosity of highly viscous liquids can be found from this curve after calculating the Viscosity Index.

the T, as is seen from a comparison of equations (9) and (10):

$$Q_G = 61C_v\sqrt{P_2\Delta P/G} \quad (9)$$

$$Q_G = 1390C_v\sqrt{P_2\Delta p/GT} \quad (10)$$

$$Q_G = 7450C_v\sqrt{P_2\Delta p/MT} \quad (11)$$

$$Q_G = 5180C_v\sqrt{(P_1^2 - P_2^2)/MT} \quad (12)$$

$$Q_G = 963C_v\sqrt{(P_1^2 - P_2^2)/GT} \quad (13)$$

The difference between gas equations (10) and (11) is that the former is in terms of specific gravity of the gas (at flowing conditions) and the latter is in terms of molecular weight (which is a better parameter in the sense that it does not vary with pressure and temperature).

The difference between (11) and (12), and between (10) and (13), lies in the use in the former of downstream pressure and Δp, whereas the latter use upstream and downstream pressures only.

Gas at Critical Flow Conditions

$$Q_G = 61C_vP_1/2\sqrt{G} \quad (14)$$

$$Q_G = 1390C_vP_1/2\sqrt{GT} \quad (15)$$

$$Q_G = 7450C_vP_1/2\sqrt{MT} \quad (16)$$

Here again the difference between (14) and (15) is only in the temperature-correction factor. The difference between (15) and (16) is that the former uses specific gravity (G), the latter molecular weight (M).

Relation between M and G

Some of the equations given for gases are in terms of molecular weight (M), some in terms of specific gravity (G). If conversion of M to G is desired, the following may be used:

$$\text{Sp. Gr. of gas} = \frac{\text{Molecular Weight of the gas}}{\text{Molecular Weight of air}}$$

$$G = M/28.97$$

Flashing

When hot liquids are being controlled by a valve, the reduced outlet pressure can cause the liquid to vaporize, or flash—if the downstream pressure is less than the vapor pressure of the fluid. A larger size valve may be required to handle the volume of vapor that flashes in the body than is indicated by the liquid-flow formulas. This is an important valve-sizing consideration, and conventional heat-balance methods of sizing control valves can be seriously in error. A method based on "apparent critical pressure drop" across the valve gives superior results for globe bodies, and should be used by persons facing this problem. The technique is reported in an article "Sizing Control Valves Handling Flashing Fluids," by Glenn F. Brockett and Charles F. King (of the Fisher Governor Company), in *Instruments* magazine, July, 1953, Vol. 26, pages 1017-1019.

Viscosity

It is generally not necessary to consider the effect of viscosity when sizing a control valve unless the viscosity of the flowing liquid is considerably greater than that of water. In cases where a highly viscous solution is to be handled, the Q equations should be corrected as follows:

Calculate the viscosity index I_v

$$I_v = 94.8\,Q_L/\sqrt{\text{Stokes x } C_v} \quad (17)$$

where Stokes is the viscosity in poises times the specific gravity of the fluid. Using I_v, obtain the correction factor K from Fig. 2-1, and divide the Q equation by this correction factor.

Conclusion

In presenting this C_v-method of calculating valve capacities, it is fully recognized that there will be discrepancies in, for example, use of the C_v factor to select a 10-inch valve for gas with 100-psi drop, as compared to 25 gpm of water at 5-psi pressure drop. Precise selection of a valve is only possible by using a flow coefficient obtained under very similar conditions. For large valves with large flow rates, this experimental work becomes impractical. Most published C_v-factors have been obtained by actual tests. The few extrapolated C_v values appearing in tables are a lesser source of inaccuracies than selection of the expected operating conditions used in choosing a valve.

Instrumentation for a Continuous

Strip Steel Annealing Line

Continuous annealing of strip steel results in a uniform end product with desired brightness and surface conditions—and in great time savings in process. Instrumentation for continuous anneal includes temperature control of furnace zones, measurement of strip temperature in the various zones, control of the anneal atmosphere, safety features, and fuel control.

A. B. CHAMBERLIN, JR.
Yorkville Works
Wheeling Steel Corporation

INSTRUMENTATION of a continuous annealing furnace is not much different from that for any bright-steel annealing equipment. It consists of:

1. Control of the furnace temperature with all necessary protective devices.
2. Accurate measurement of the product temperature.
3. Control of anneal-atmosphere conditions commensurate with surface quality of the product and good safety practice.
4. Measurement of fuel consumption for efficiency and accounting purposes.

The Wheeling line (Fig. 1) illustrates some of the details of instrument problems encountered in such an installation. It is a 300-fpm strip-steel annealing line with an average monthly production rating between 7.5 and 8.5 tons per hour. The furnace section is heated by the combustion of either desulfurized coke-oven gas or natural gas with a maximum heat input of 12,000,000 BTU per hour. Sixty-six 5-inch-diameter U-type radiant tubes of alloy steel heat the six zones of the first three furnace passes. There are two zones in each of these passes.

DX gas is used as the annealing atmosphere.

Dimensionally, it is a 42-inch line with an over-all length of approximately 100 feet and a height of approximately 40 feet; 1200 to 1400 feet of strip are required to completely thread the line.

The strip-handling equipment consists of uncoiler, welder, bridle rolls, elevator towers, furnace section (comprising heating, holding and controlled cooling sections), eight water-jacketed cooling chutes, two forced-air cooling chutes, tension bridle rolls, upcut shear, and tension reel (equipped with hydraulic traverse actuated by a photoelectric cell for coil edging control.)

Furnace Temperature Control

Each of the six heating zones are individually controlled. Two temperatures (zone temperature and radi-

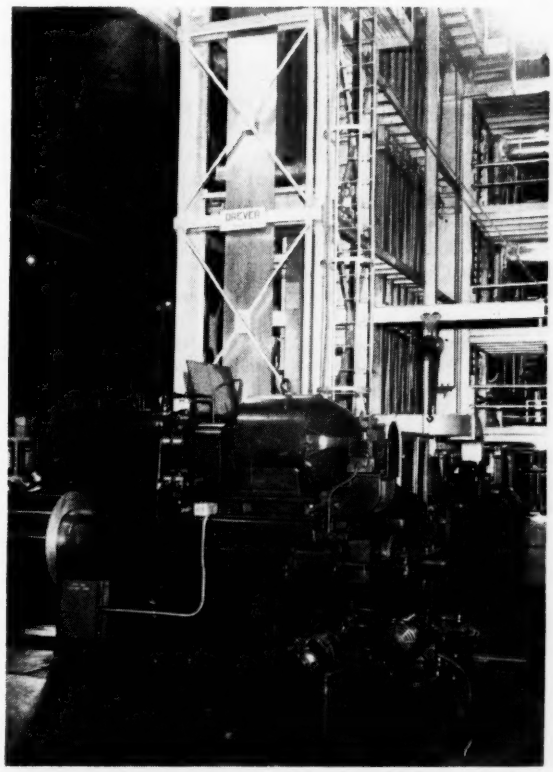

Fig. 1. Delivery end of the continuous annealing line at Yorkville Works of Wheeling Steel Corp.; Furnace accommodates 42-inch line, has a length of 100 feet and a height of 40 feet; 1400 feet of strip are required to thread the line.

Presented at Conference on Instrumentation for the Iron & Steel Industry, Pittsburgh, 1955.

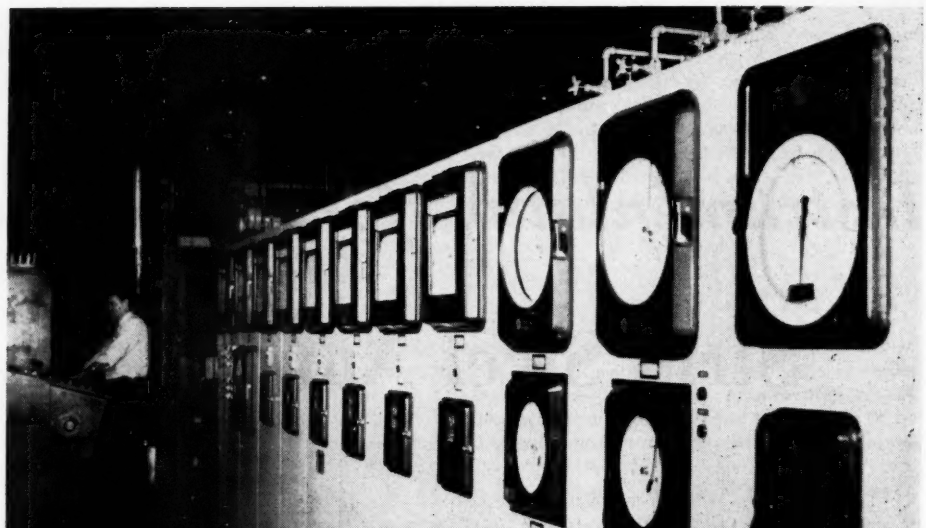

Fig. 2. Main instrument panel for the continuous annealing furnace.

ant-tube temperature) are measured in each zone. Chromel-alumel thermocouples are used for temperature measurement.

Zone temperature is measured by a thermocouple whose tip is located at the point where the center lines of the furnace and the tube assembly intersect. This measurement of furnace temperature is taken at one of the last tube placements of the zone; it thus represents the final zone temperature. The thermocouple well can be mounted directly on the radiant tube face plate or it may be mounted to the furnace shell.

The *radiant-tube temperature* is measured by a thermocouple which is located 1 inch away from the mid point of the side surface of the radiant-tube return bend between the return bend and the furnace wall. This temperature (preferably measured at a different radiant-tube placement from that used for zone-temperature measurement) provides protection against overheating of the radiant tubes. Both the zone and tube temperatures are recorded on a 2-point instrument (Fig. 2) which registers dots and dashes to distinguish between the two readings. The dash is the zone temperature, which controls the firing rate of the individual zone. The dot records the tube temperature and has no effect on control of the zone unless the tube temperature reaches the maximum safe limit, which is set at 1850°F. When the limit is reached, the slide wire is short-circuited and the control valve closes until the tube temperature drops below the limit, at which time the safety circuit is de-energized and normal control is re-established. Tube temperatures generally range about 30 to 50 F° above the zone temperature and could be used, temporarily, for control purposes in the event of failure of the zone-temperature radiant tube or thermocouple.

The zone-control instrument is a 2-point recorder-controller with rate, reset (droop), and proportional-band (throttling-range) adjustments. As a 2-point instrument is used, the control circuit is energized 25 minutes of every hour. The control-circuit relay is equipped (at the main panel) with a manual-automatic switch that permits manual operation of the control valves.

The control valves are adjustable-port air-gas proportioning valves. They regulate the flow of fuel to the individual zones.

A 2-stage pressure-regulating system is employed to maintain constant upstream pressure at the control valves. A coarse regulator, which is pilot operated, reduces the 25- to 45-psig gas-line pressure to 3.5 psig. After passing an electric safety-shut-off valve and a pressure switch, this 3.5-psig gas pressure is further reduced to a pressure of 13 to 15 oz per sq in by a pilot-loaded regulator.

Safety Features

The combustion-air supply is tapped for the pilot loading; therefore, a failure of combustion air automatically shuts off the gas. In addition to this safety feature, the solenoid safety-shut-off valve will be closed (electrically) by the gas-line-pressure switch, an additional combustion-air-line pressure switch, or a power failure.

There are two different alarms near the operator's station to warn of either fuel or combustion-air supply failure.

Measurement of Strip Temperature

Thermocouples measure the strip temperature in each of the six heating zones. The temperatures are recorded on a 6-point recorder.

The thermocouples used to measure strip temperature are, in general, located at the end of each pass in such a way that they are not exposed to direct radiation from the radiant tubes. Each pass in the furnace is separated by refractory division walls; the top and bottom of each

pass has a 9-inch restricting throat through which the strip passes. This construction protects the thermocouples and also protects the furnace rolls from direct heating-tube radiation.

The primary elements are approximately 6 inches away from the strip and are of the closed-end type, except one —the thermocouple measuring strip temperature at the end of the sixth furnace pass. This one is of the open-end type, with a 2-inch copper disk welded to the tip to collect more radiation from the strip.

In addition to the six thermocouples for strip temperature, there is also a radiation pyrometer (Ray-O-Tube) recorder-controller whose primary element is located at a point where the highest strip temperature is likely to occur. The sighting tube is a piece of 4-inch alloy-steel pipe, and is positioned over the center of the furnace roll immediately following the last heating zone. The target end of the sighting tube is about 6 inches from the strip. A quick-opening valve is located between the Ray-O-Tube and the sighting tube to provide closure for maintenance and emergency protection of the Ray-O-Tube unit.

As DX gas (the annealing atmosphere used in the furnace) is cloudy, it tends to interfere with accurate temperature readings with a radiation-type instrument. Therefore, about 350 cfh of HNX gas are fed into the sighting tube to provide a clear atmosphere around the target area for accurate temperature measurement. The HNX gas also serves to cool the Ray-O-Tube.

The Ray-O-Tube and the thermocouple near it never differ more than 20 F°, and they are usually within 10°. For this reason it is felt that fairly accurate strip-temperature is being recorded.

Still under consideration is the possibility of tieing the control feature of the Ray-O-Tube instrument to the line-speed rheostat.

Atmosphere Control

Safe control of the annealing atmosphere requires measurement of: (1) furnace pressure resulting from the application of controlled atmosphere gas, (2) combustible content or analysis of the atmosphere gas, (3) the dew point of the gas, (4) the flow of atmosphere gas for cost accounting purposes, and (5) the regulated line pressure of the atmosphere gas.

Furnace pressure is measured at two different places on the line—just above the entry and exit gas seal rolls. The respective reference impulse connections are located just above the same rolls on the outside of the furnace so that the pressure difference at each set of seal rolls is indicated. These pressure differences are recorded on two separate recorders.

Protection against a possible explosion of the DX gas in the furnace is provided by a stand-by supply of nitrogen bottles for purging in the event that a power failure shuts down the atmosphere-generating equipment.

Sampling System

An extensive gas-sampling system provides fourteen different sampling points on the furnace for the combustibles recorder. This sampling system makes it possible to check the furnace completely for purging, which is important for the safe handling of DX gas. The same system is used also for checking furnace dew points and extracting gas samples for complete analyses for metallurgical purposes.

A standard centrifugal-type gas booster-blower is used to extract the gas sample and deliver it to the combustibles recorder with sufficient pressure to properly operate the analyzer section. The gas-sampling system has been satisfactory.

DX-Gas and Fuel Control

DX-gas consumption is measured by a recording-integrating-type flowmeter. Immediately adjacent to the flowmeter is a push-button station which operates a motor valve in the DX-gas supply line. This permits convenient adjustment of DX-gas flow and furnace pressure at the main panel.

In keeping with the standard practice for atmosphere-gas applications, the regulated pressure of the DX-gas supply to the furnace is also recorded; the record supplies pertinent data in event of equipment failure.

Fuel consumption figures for purposes of efficiency and cost distribution are provided by a recording-integrating flowmeter. In addition to the recording of flow, a separate 2-pen instrument records both the gas temperature and pressure so that accurate fuel figures may be compiled. Both desulfurized coke-oven gas and natural gas may be used by the furnace; however, the difference in supply line pressure between the two fuels just counteracts the difference in the specific gravities, with the result that direct reading of the flowmeter chart is accurate for either fuel. Therefore, no change in the instrument is required when fuels are switched.

In conclusion, the basic difference between the continuous strip-steel annealing (described) and the batch-type coil annealing is in the time required in process—namely, seconds for the continuous line compared to hours for the batch equipment.

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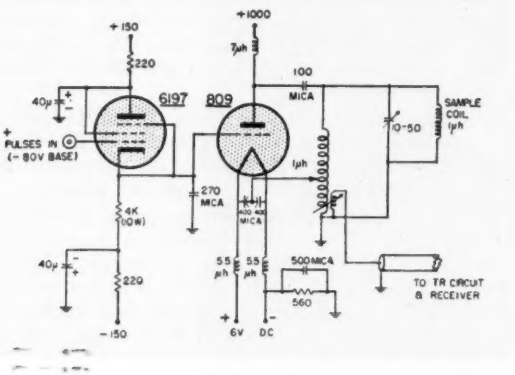
32-Mc PULSED OSCILLATOR

This gated 32-Mc Hartley oscillator is used to obtain oscillating magnetic-field pulses in spin-echo work. These r-f pulses, of 5- to 10-microsecond width, condition the nuclei of hydrogen (in water or glycerine) in the sample volume to produce delayed echoes of the input pulses.



The grid of the 6197 cathode follower is normally biased to −80 volts, thus holding the 809 cut off. Positive input pulses of the desired width and of 50 to 100 volts amplitude permit the 809 to oscillate, with the amplitude of oscillation a function of the input pulse amplitude.

Output of the 809: pulsed 32 Mc as gated by the input pulses to the 6197. The input voltage amplitude at the sample coil is of the order of hundreds of volts peak-to-peak. The output voltage at the TR and receiver is one to two millivolts maximum.

Supply Currents: 20 to 40 ma at ±150 v, and 0 to 100 ma at + 1000 v, with the average currents needed dependent upon pulse repetition rates. In the actual set-up the ±150 supplies were regulated, but this is not necessary. The 1000-volt supply was not regulated.

Source: A. G. Anderson, R. L. Garwin, E. L. Hahn, J. W. Horton, G. L. Tucker, and R. M. Walker, IBM Watson Scientific Computing Laboratory, Columbia University, New York, New York; also *Journal of Applied Physics*, Nov. 1955.

SELF-BALANCING PHASE INVERTER

Phase inverters are commonly used to derive a push-pull output from a single-ended input. This unconventional self-balancing circuit was devised for an extremely low-distortion audio amplifier. To obtain lowest distortion, and to permit use of generous amounts of negative feedback, it was required that the push-pull signals at the phase inverter output be precisely matched in amplitude and closely 180° out of phase.

The 12AX7 tube (V1) is the basic phase inverter. Tube V2b (one half of a 12BZ7 dual triode) provides essentially a high a-c resistance load for the common cathodes of V1. Input signal applied to the grid of V1a produces a corresponding cathode voltage which acts as the input to V1b. As this cathode signal is in phase with the input to V1a, the output developed at the plate of V1b is out of phase with the output of V1a (this is the basic phase inversion); the two outputs are nearly equal in amplitude.

The circuit functions to correct any remaining phase and amplitude unbalance in the outputs of V1 in the following way: The two 100K resistors across the outputs of the cathode followers V3a and V3b are closely matched. Any unbalance in phase and amplitude of these outputs produces a signal at the midpoint, which is applied via cathode follower V2a to the grid of V2b. The error is amplified in V2b and applied to the cathodes of V1; the polarity of this feedback is such as to correct the original unbalance. Outputs remain closely 180° out of phase at all frequencies from zero to above 500 kc.

Tube V2a acts as a d-c voltage divider to obtain proper bias for V2b; it could be replaced with a resistive divider.

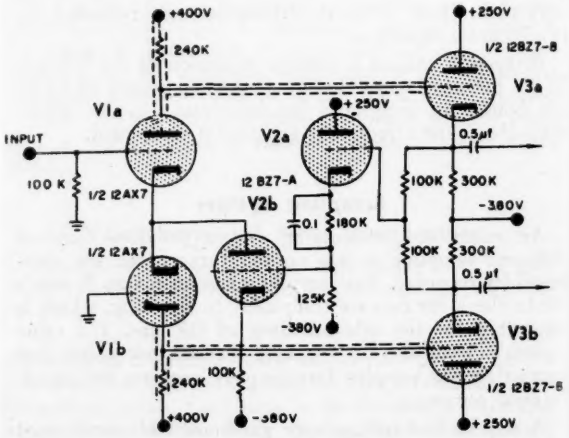
Negative feedback can be applied to the circuit by applying a portion of the output of V3a (via a blocking capacitor and voltage divider) to the normally grounded grid of V1b. Note that such feedback would be from the *top* half of the output 12BZ7 to the bottom half of the 12AX7.

Signal accommodation: Maximum input signal can be as large as 2 v rms.

Degree of balance: In-phase signal at output is reduced to 10^{-3} to 10^{-4} times the out-of-phase signal for equal in-phase and out-of-phase input signals.

Gain: from input to either output: about 30-31 db.

Frequency Response: No lower limit; 3 db down at 260 kc.



CIRCUITRY

The circuit is the heart of all electronics. Here are four more basic and interesting circuits. Unless marked, resistors are in ohms, capacitors in microfarads or (in r-f circuits) in micromicrofarads.

B Supply: —380 v dc at 7.6 ma; +250 v dc at 5.4 ma; +400 v dc at 2.2 ma.

Source: J. R. Macdonald, Texas Instruments Inc., 6000 Lemmon Ave., Dallas 9, Texas. Also *IRE Transactions on Audio*, Vol. AU-3, No. 4, July-Aug., 1955.

FREE-RUNNING MULTIVIBRATOR For 200-2000 PPS

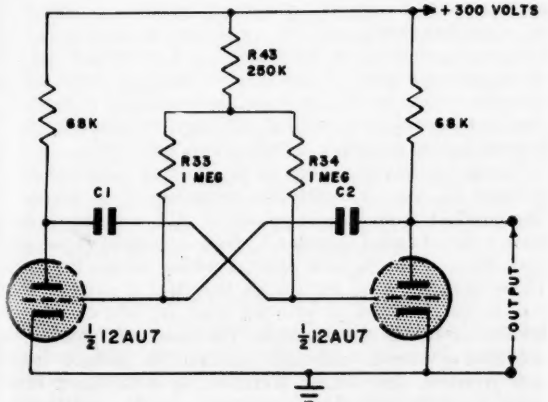
This multivibrator has been used in military equipment for a number of years as a pulse-repetition-rate generator. It is available in module form (G1001) from supplier; frequency-determining capacitors C1 and C2 are external. Circuit is derived from circuit developed in the NBS-BuAer Preferred Circuits Program.

Equal values of C1 and C2 are used when the output is to have equal on-off times; these may be determined from the formula:

$$C1 = C2 = (0.79 \times 10^6)/f$$

where f is the desired repetition frequency, and C is in uuf. Circuit shown has practical frequency range of 200 to 2000 pps.

Duration of a quasi-stable state depends on several things, including (1) the RC time-constants of the timing networks—C1, C2, R33 and R34, (2) the initial voltage from which the timing waveform begins, (3) ultimate voltage that the timing waveform would reach if permitted to do so, and (4) the critical voltage at which the transition occurs. Stabilizing the duration is equivalent to stabilizing these four quantities, or making their effects cancel out.



Circuit stability is improved when the grids are returned to a positive voltage, as in this circuit, because the grid voltage of the cutoff tube is rising more steeply when the tube begins to conduct. Thus the time when the tube starts to conduct is more sharply defined than when the grid return is to ground. However, the circuit remains sensitive to heater and plate supply voltage—about 0.5% change in frequency results from 10% change in heater or B+ supply. Circuit is considered as a moderately stable repetition-rate generator.

Output: 260 v peak to peak (excludes overshoot).

Frequency range: 200 to 2000 pps, depending on C1 and C2.

Stability: About 0.5% change in frequency for 10% change in either B+ or heater voltage.

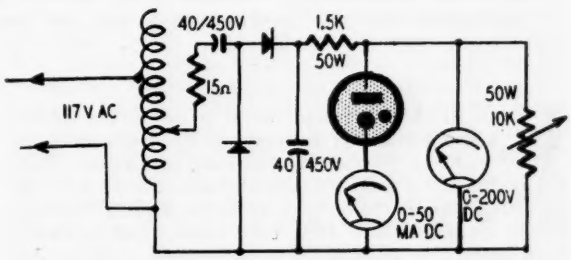
Rise Time: Depends on frequency because when tube cuts off, the timing capacitors must charge through the 68K resistors. Hence rise time is much longer than fall time—when tube conducts and shorts out the circuit capacitors.

Fall Time: 0.04 usec into 10K and 20 uuf load.

Source: Aerovox Corp., 1200 Jefferson Davis Highway, Arlington, Va.

VR-TUBE TESTER

A voltage-regulator (VR) tube is a gas-filled 2-electrode tube which maintains a constant voltage drop across its electrodes over a range of current through the tube and, therefore, is used as a source of constant potential. Important factors in a VR tube are starting voltage (voltage required to initiate gas ionization), minimum tube current (current at which voltage reaches its rated value), maximum tube current, and operating voltage (constant voltage output). For example, the VR75 (or OA3) operates at 75 volts output, but requires 100 volts to start, and maintains its 75-volt output over a range of 5 to 40 ma through the tube.



Tube	Approx. starting volts D.C.	Min. Tube ma	Max. Tube ma	Approx. oper. volts
0A3/VR75	100	5	40	75
0B3/VR90	125	10	30	90
0C3/VR105	115-135	5	40	105-108
0B2	115	5	30	105-108
0A2	155-156	5	30	150-151
0D3/VR150	160-180	5	40	150-153

This circuit applies variable zero-to-200-v supply and variable zero-to-10K load to VR tube to check (1) starting voltage and operating voltage at various loads and (2) tube currents at various voltages and loads. Voltage-doubler supply and variable autotransformer are used to produce 200 volts (maximum) with 117-v line voltage. Selenium rectifiers in voltage doubler are rated at 150 ma, 130 v. Characteristics of typical VR tubes are shown in table.

Source: J. Sodaro, *Radio-Electronics*, Nov., 1954

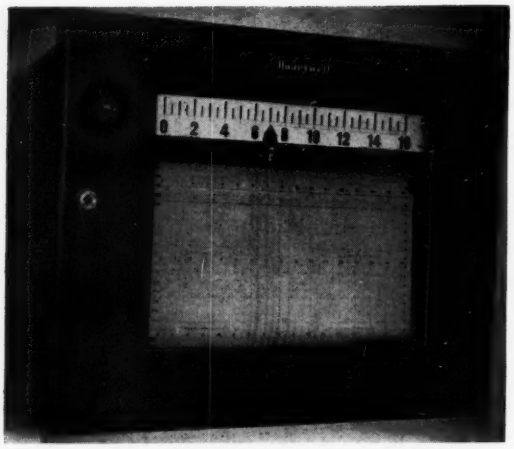


Fig. 1. Multipoint recorder of Minneapolis-Honeywell Regulator Company.

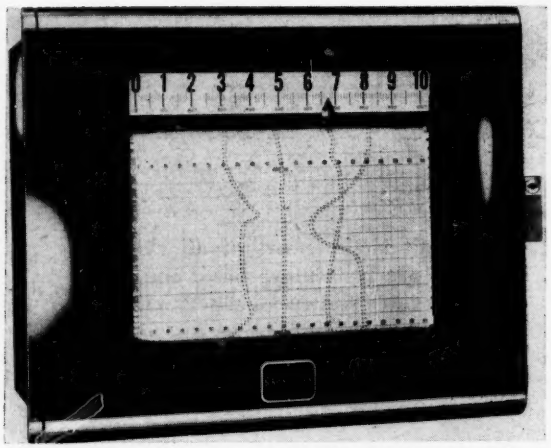


Fig. 2. Multipoint recorder offered by the Bristol Company.

The Steel Industry Has Plans for

Multipoint recording facilitates interpretation of data and can lead to better production methods. This article reviews the trends and plans that the steel industry has for multipoint recorders.

J. A. MILNES
U. S. Steel Corp.

U. S. STEEL'S Fairless Works is one of the largest and most comprehensive production units in existence. On the 3800-acre site in Fairless Hills, Pennsylvania, 75 miles of railroad track and 20 miles of roads link the various sections of the huge plant. Fairless Works include an ore dock, coke ovens, blast furnaces, open hearths, a 45-inch slabbing-blooming mill, an 80-inch hot-strip mill, a 40-inch blooming mill, a 30-inch and a 21-inch billet mill, a 10-inch bar mill, and a complete sheet and tin mill.

Correlation of Scattered Data can be Simplified

The integration of the various complex processes into an efficiently operating plant requires a high degree of coordination and control. Indicating and recording the vast amount of information necessary to maintain this control has resulted in an increase in the number and complexity of control stations and in an accumulation of scattered data. Correlation and interpretation of the data is sometimes a real problem when it is necessary to refer to many separate recorder charts, usually of different types and styles. The modern solution to this problem involves the use of centralized data-recording systems. A first step in this direction is the use of more multipoint recorders to record a number of variables on a single chart.

Multipoint Recorders Helpful in Storing Data

Multipoint recorders might be used advantageously in increasing the service life of components of a hot-strip mill. One operator can adjust the relationship between strip tension and screw-down pressure between stands in such a fashion that no part of the mill is subjected to an excessive load, even during transient conditions, with the result that maximum service life is obtained for the various components. Another operator can adjust the various load relationships in a different manner, and although the product may be identical with that produced by the first operator, the wear on the mill during certain periods may be excessive, causing an early mechanical failure.

If a multipoint recorder were connected so that as many of the operating variables as possible were recorded in a form as condensed as practicable, the various measurables could be quickly compared, both on a time and on a product basis, and the cause for variations in the relationships could be determined and corrected. Or, if all operators controlled the line in identical fashion the recorder would quickly indicate the beginning of a weakness in the machinery so that maintenance could be performed before complete deterioration occurred.

Variations in the *quality* of the product might also be reduced by use of multipoint recorders. For example: The product from a cold-reduction mill sometimes contains a defect called "chatter," which is evident as parallel dark lines, about ¾ inch apart, running across the strip. These lines show up even when the steel is painted, and cannot be tolerated in product used in fabricating car fenders or hoods, for example. The cause of "chatter" is not always known, although possibilities include faulty roll grinders, the rolling lubricant, spot-hardened bearings, poor scalebreaker operation on the continuous pickling line, or faulty hot-strip processing. "Chatter" ha

Presented at Conference on Instrumentation for the Iron & Steel Industry, Pittsburgh, 1955.

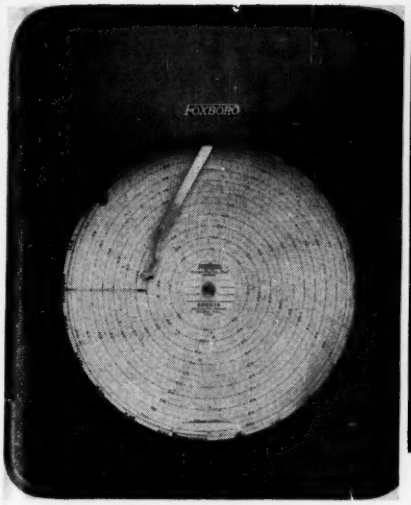


Fig. 3. Multipoint recorder of the Foxboro Company.

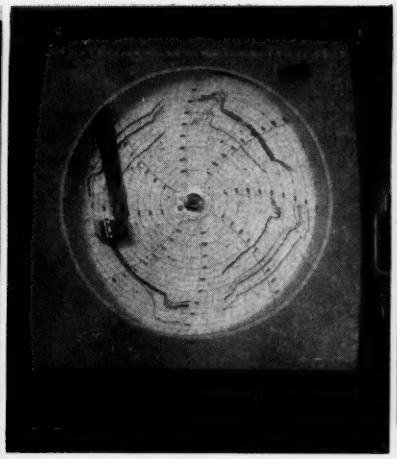


Fig. 4. Quadrant-type recorder of the Fielden Instruments Div., Robertshaw-Fulton Controls Co., can record up to 96 variables.

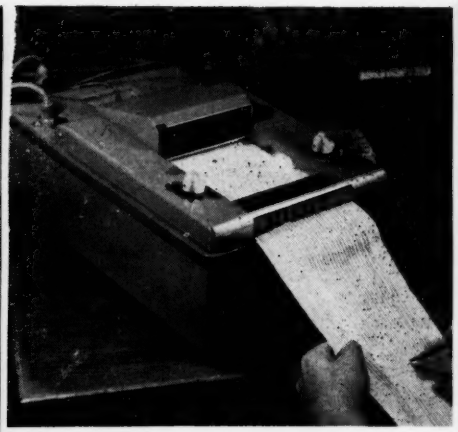


Fig. 5. Multipoint recorder of the Alden Electronic & Impulse Recording Equipment Co. uses electrosensitive recording of up to 30 variables.

MULTIPOINT RECORDERS

been improved in the past by carefully checking various components and correcting those that appear faulty. With multipoint recorders storing information concerning the operating characteristics of related processes, the conditions prior to the existence of the defect could be compared with the conditions after the appearance of the defect, with the possible result that the cause could be determined more readily.

Multipoint Recorders Find Points Where Control is Needed

Multipoint recorders might also be useful in planning process-design changes, especially in indicating the points at which control could be or should be applied. An example might be a recently made change in cold-reduction gage-control method. Before the change, normal practice was to measure strip gage at the delivery end of the mill, and to control the thickness by controlling the tension between the last two stands. A recent installation of a thickness gage following the first stand, with provision for controlling the screw-down motors of the first stand in response to the gage indication, showed that closer control of gage could be achieved, with less need for adjustment of the subsequent stands.

The analysis of such an installation would be considerably simplified if a multipoint recording of the important variables were available. Likewise, new control methods on other lines or processes might become apparent if sufficient data from multipoint recording charts were available for correlation and interpretation.

Specially Designed 14-Point Recorder

Currently, the U. S. Steel Applied Research Laboratory is investigating the applicability of a 14-point recorder specially designed to simplify correlation of recorded information on the operation of an electrolytic tinning line. The main function of a tinning line is to plate tin onto steel in carefully-controlled amounts. However, for various reasons, a number of other operations must be performed on the strip during its passage through the line. The steel surface must be properly treated prior to the plating operation to prepare the surface for the tin coating. After the plating operation the tin coating must be melted and quenched to produce an acceptable surface finish, and then the plated surface must be chemically treated and oiled for protection during storage. The speed of such a line varies from a few hundred to over 1000 feet per minute, and most of the aforementioned operations must be regulated according to speed.

It can be seen that the effect of one operation upon another, or the effect of variations in operating conditions from time to time, is not easily determined, and that a centralized data-recording station would be most desirable. The recorder mentioned will be used to obtain a centralized comprehensive history of the operation of a tinning line. Measurables such as line speed, cleaning current, plating thickness, strip width and thickness will all be recorded by the one device. This device can record 12 line variables semicontinuously on two sections of a split chart, six in each section. The six variables in each section are recorded in different colors, for easy identification. Two pens (one pen on each side of the dual chart) indicate "on-off" type information. The resulting charts will be evaluated to determine the interdependence of the operations and the effect of various operating conditions on the quality of the tin plate.

Such charts should be useful not only to design engineers, but also to operating, maintenance and metallurgical personnel.

As new high-speed equipment is developed for recording and analyzing centralized data, this equipment will undoubtedly be incorporated in the design of new and improved processing lines. In the meantime, use of available multipoint recorders on complex processes should provide valuable information.

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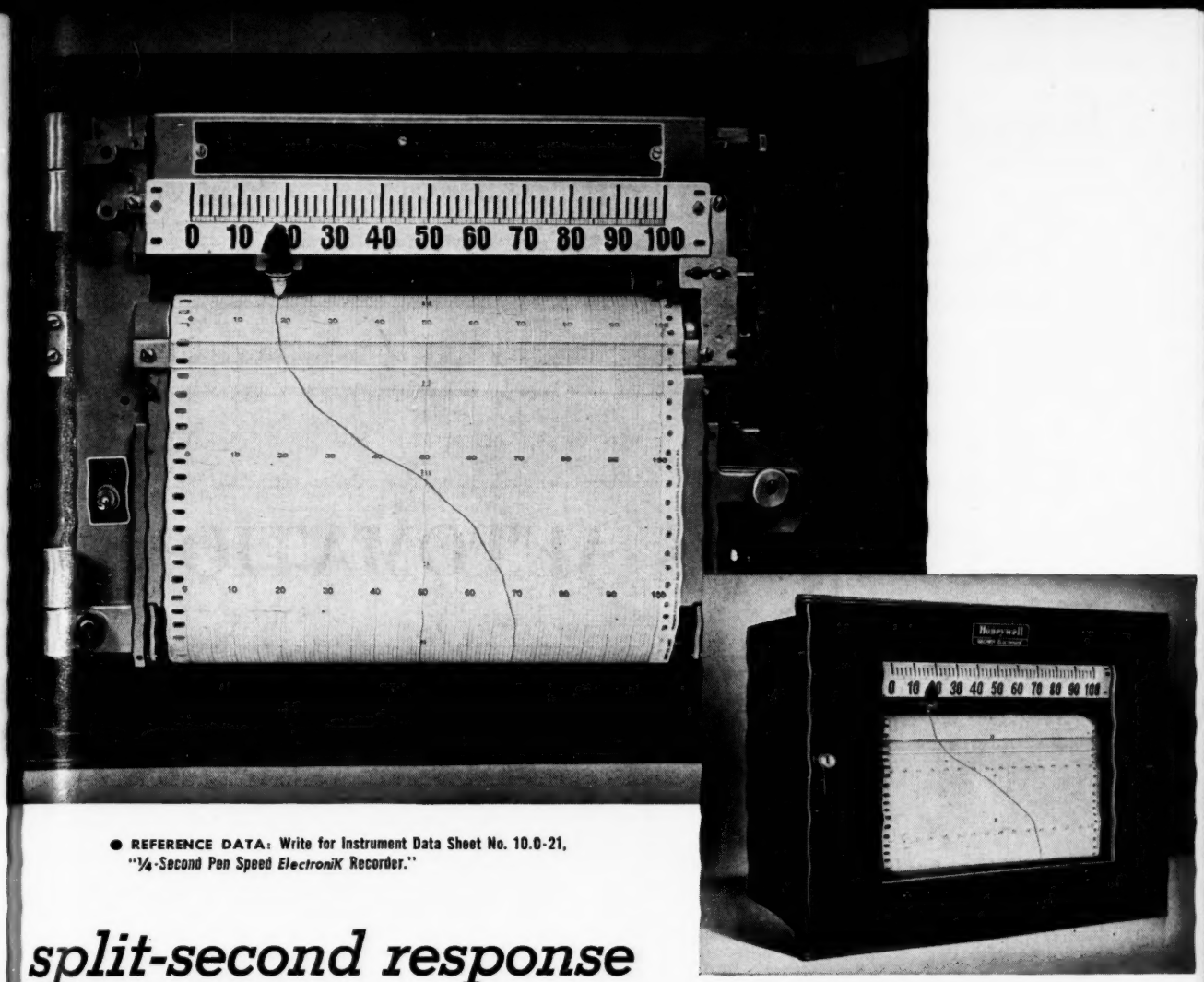

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Trends in PROCESS AUTOMATION

This résumé of past trends in process automation first defines the present goal, then predicts future trends—data processing, product analysis, and computer control.

GLENN G. GALLAGHER
and
ROBERT A. ROBINSON
The Fluor Corporation, Ltd.

PETROLEUM REFINING is probably the most fully automated of the continuous process industries in existence today. There is a good reason for this advanced position. Inherently, continuous-flow petroleum processes lend themselves more readily to complete automation than do processes which require physical manipulation of solid materials.

Automation can be divided into two basic problems: (1) *Work Operations*—where changes are made to feed stocks, and (2) *Transfer Operations*—where feed stocks are transported and positioned for the work operations to be performed. It is the ease with which these transfer operations are accomplished that gives petroleum processing a big advantage over other industries.

For example, consider the transfer control problems involved in a steel mill where ton-sized articles must be transferred physically from one rolling machine to another, or the transfer problems in an atomic energy process which requires remote manipulation of products by means of television cameras and elaborate mechanical hands, or the transfer problems in the automotive business where engine blocks must be moved and positioned accurately.

Contrast these problems with the refinery where tons of material are also transferred (such as the feed from a preparation unit to a Cat. Cracker). The feed is passed continuously through pipes and other equipment under automatic control at all times, with no human manipulation or supervision required. You can't see the movement of these tons of materials. In fact, you can't see *any* of the process variables without instruments, except possibly level.

Owing to the fluid nature of the materials handled, and other inherent features compatible to automation, we find this industry in front, with the closest present-day approach to a completely automatic factory.

Paper prepared for the ASME Petroleum Mechanical Engineering Conference, Sept. 25-28, 1955, New Orleans, La.

March Meeting: *Wednesday, the 21st, Rio Hondo Country Club, Downey, Calif.*

Feature: *Joint Meeting with Los Angeles Section of the ISA. Speaker: D. J. Bergman, Universal Oil Products Co., will present a paper "Instrumentation of a Fluid Catalytic Cracking Unit."*

Defining Our Goals

Before discussing future trends, let us define our goal as it looks to us today. Defining a goal may help us separate future trends from future fads.

It is within the scope of present-day instrumentation to design a refinery which would start up and shut down at the push of a button, repair itself to a limited extent, and otherwise meet minor emergencies. In between these utility functions, our plant could be made to operate itself automatically and efficiently with regard to the economic processing of feed stocks to meet market demands.

Perhaps the term "repair itself" needs a little explanation. Our processes accomplish this feat to a limited extent today. We often install spare pumps instrumented so that they start automatically on the failure of the main pump. Emergency turbo generators and instrument air systems are other familiar examples. In the *completely* automatic factory this technique would need to be used more extensively than today.

Can we justify this complete automation economically—or is it even desirable technically? The answer, at this time at least, appears to be "*no.*" Refineries now operate at a nearly irreducibly low operating manpower level per plant; these men are necessary to safely meet emergencies.

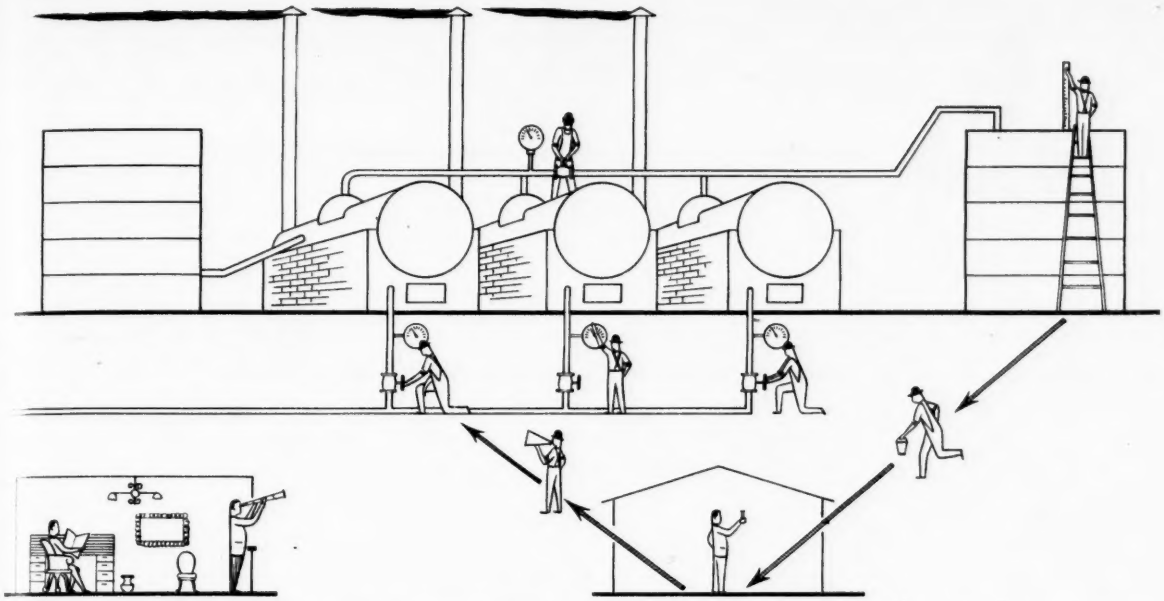

Fig. 1. The petroleum refinery of yesterday had many men—watching indicators, turning valves, gaging tanks, running samples.

We can upgrade these men technically by automatically doing their routine tasks, but we still need them in attendance for safety reasons and evaluation of the process. Economically speaking, therefore, we should not duplicate with equipment some of the tasks these men can do better or cheaper. These same men can start up and shut down the plant, rather than employing specialized start-up equipment. It hardly seems economical to automate such functions as turning water on and off to condensers, opening block valves, etc.

Future processes must be designed with inherent susceptibility to control. At present, units are designed too often without regard to controllability, and then someone later stands back and instruments a plant like a man throwing darts at a dart board.

Let us define our goal, therefore, as a process that will not necessarily start itself but which will, when started, continue to operate itself economically and precisely, and effect minor repairs until shut down. This operation will include analyzing feed stocks and markets to produce the required product purity and quantities automatically.

With this goal in mind, let us look to the past and present to see what trends have been established.

Past Trends

Not many years ago the control element for a process consisted of a man who watched an indicator and manipulated a valve to maintain a desired reading (Fig. 1). When the limits of this man's capabilities were reached and it was not practical, or even possible, to increase production by adding more men, the controller was invented. This little box relieved the man of the tedious job of keeping the indicator on the desired set point, and upgraded him. His scope now included supervising many controllers, which required a broader over-all knowledge of the process.

As processes became more complex and large, it became necessary to centralize the control mechanisms so that they could be more efficiently supervised by the human operator (Fig. 2). It became increasingly important to measure new process variables and to use them for control. There was also a constant improvement and refinement of the control mechanisms, the operator's working tools. This is a phase of progress that is more or less taken for granted. With the wide acceptance of automation and centralized control rooms, one of the operator's principal routine chores now is keeping a log sheet and watching for possible trouble.

Progress, in the past, has established three basic trends:

1. Reduction of the human links in process control.
2. Development of new measuring devices which more completely define product composition.
3. Continued improvement of established equipment.

Our progress with these established trends toward our defined goal will eventually involve a fourth trend which is beginning to form at this time.

4. Computer control.

Present control mechanisms are sometimes called "error type" because they require a deviation from their set point to produce a corrective action. With a coordinated computer-type control system, the instruments downstream from a disturbance will be advised that a change is coming. A corrective action can then be made in anticipation of the change. Therefore, no deviation (or error) from the control point need take place. Computers can, with proper input signals, analyze feed stock, product quality, markets, and operating economy—and dictate control conditions.

Future Trends

Let us examine these trends and predict their future course toward our goal. We still have slow error-pro-

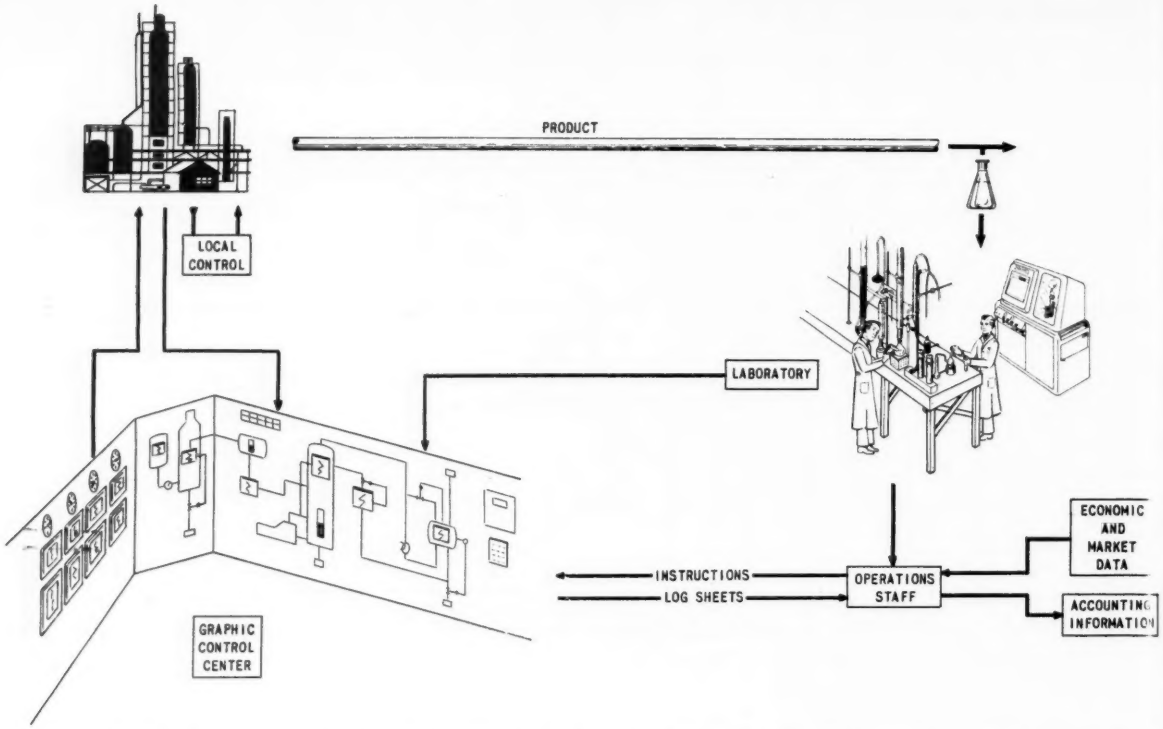

Fig. 2. The petroleum plant of today has a nearly irreducibly low amount of operating manpower, and features a graphic control center. Present weaknesses lie in the time lags inherent in manual data logging and manual analyses via remote laboratories.

ducing human links in our present control picture. One of the most unsatisfactory is our method of collecting and handling data. This is true not only of the process units but also of accounting and front-office procedures.

Probably one of the largest single bits of human drudgery left in operations is keeping the log sheet. The log sheet should indicate the pulse of operation. It should provide a vital source of corrective information on the behavior of the process during upsets. Consider how ineffectively this procedure functions today. Some refineries require that as many as 360 points be logged each period in one control center. Owing to the time required to read and record this much information, it is humanly possible for one person to log only on a two-hour basis. There is often 1 hour or more between important entries, thus destroying the relative time relationship of the data. To

OPERATORS John Smith, William Jones, Henry White — LOG SHEET — RUN NO. 37 — PLATFORMER UNIT — STREAM — DAY NO. 12 — DATE June 10, 1954

	TIME	STRIPPER				CHARGE HEATER												HYDROGEN REACTOR			SEPARATOR 1					
		FEED PRESS	NAPHTHA	GAS	LEVEL	HEATER 1	HEATER 2	FEED	COIL OUT 1	COIL OUT 2	COIL OUT 3	COIL OUT 4	COIL OUT 1	OUT 2	RECYCLE	FEED	REACTOR	EFFLUENT	OFF GAS	OFF GAS	HI LIQUID	DRY SIDE	PRODUCT
		P1	P2	P3	L1	T6	T7	T8	T9	T10	T11	T12	T13	T14	F4	T15	T16	T17	P24	P25	L2	L3	L4
X	01:00	95	480	73	47	600	625	275	400	500	400	500	650	650	98	666	960	890	575	48	51	50	52
X	02:00	95	481	72	46	601	625	273	397	503	402	497	648	649	97	660	965	891	575	49	50	52	51
X	03:00	94	480	73	48	603	624	276	399	502	399	501	647	650	98	663	962	896	574	48	50	51	51
X	04:00	95	479	73	47	602	620	279	401	499	401	500	649	653	98	664	957	896	571	48	51	50	50
X	05:00	92	481	72	48	601	619	281	398	503	400	502	650	649	97	661	960	895	570	49	52	49	50
X	06:00	95	480	73	46	605	625	275	400	500	400	500	650	650	98	666	960	890	575	48	51	50	52
X	07:00	95	481	72	46	609	625	273	397	503	402	497	648	649	97	660	965	891	575	49	[illegible]	52	51

Fig. 3. Trend to automatic data logging is well established. Scanning mechanisms monitor all variables between logging periods.

add to this unhappy circumstance, it is not uncommon to have a plant upset at the normal log period. This demands the operator's time, so he is forced to skip taking the actual readings, or duplicate the previous ones. Unfortunately, this information is the very data that is needed if we are to prevent further recurrences of these upsets and reduce rerun and down time.

The future trend to automatic data-handling and data-reduction equipment is firmly established. At the present time there are approximately 5 operating refinery installations of automatic logging equipment and 4 more known to be in the planning stage. These data-handling machines not only print the hourly log sheet in a matter of minutes (Fig. 3), but may be equipped with scanning mechanisms to watch over critical points between logging periods. Any off-normal points will sound an alarm and be printed on the log sheet by a separate typewriter. With a little additional equipment, the machine can also manipulate process quantities into usable accounting data and transmit this information to a remotely located accounting division. Furthermore, it can reproduce the data in some directly usable form, such as a ledger or punched card.

With this automatic data-handling equipment, we have a new tool of tremendous future importance. What will this mechanism accomplish for us? It will give us infinitely more accurate data. First; because human error and intentional falsification will be eliminated. Secondly; the data at the beginning and end of the log period will be in phase, whereas present manual logging may be from 0° to 180° out of phase. We will obtain data not previously obtainable by the human element in the chain. The value of log sheets, as taken today, is questionable. Suppose we are taking the hourly log for a gas concentr-

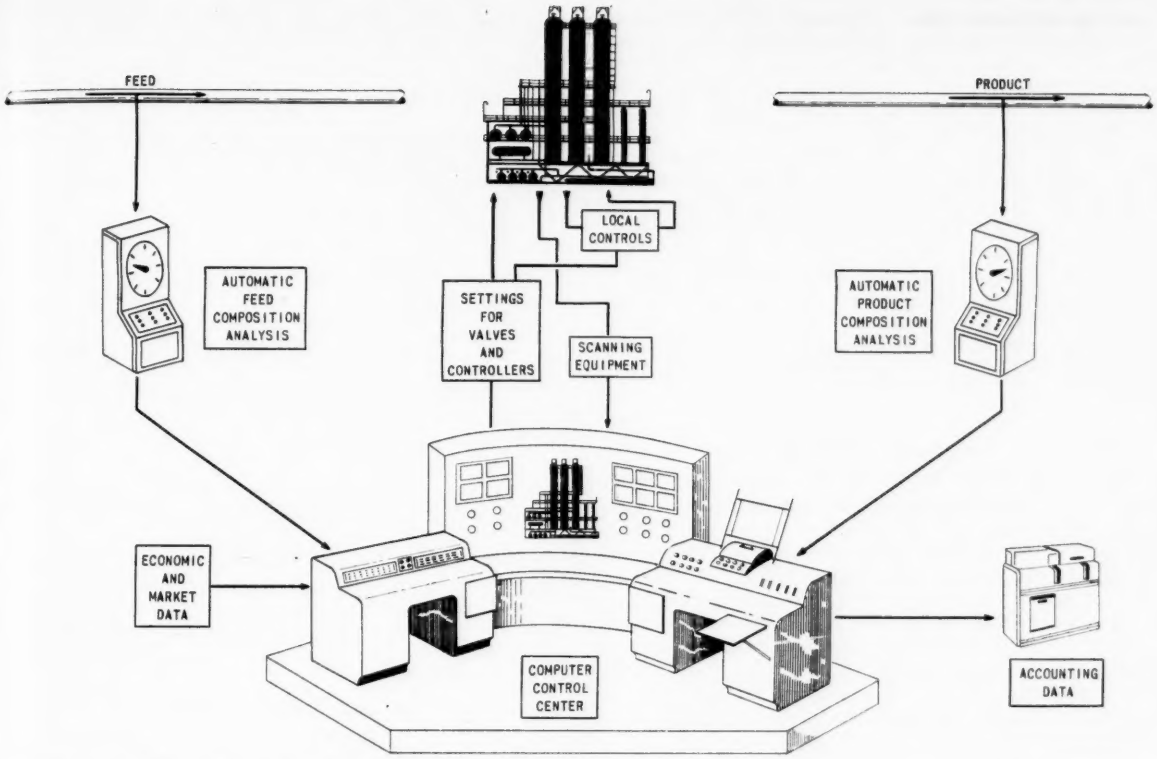

Fig. 4. The petroleum plant of the future may feature on-stream feed and product analyzers, optimalizing-type computers, and automatic tie-in with market data and the accounting department.

tion unit. If we are fortunate to be logging the Depropanizer at the instant an upset commences in that unit, we have a rare piece of data. On the other hand, if the upset occurs at some column downstream of the Depropanizer at the logging time, its origin may be difficult or even impossible to determine. Upsets may occur and be controlled between log periods and never show on the log sheet because of this out-of-phase condition in our present methods. With data-handling equipment, plant upsets can be watched as they originate and progress through the entire chain of processes.

A Process Scanner with off-normal printing would detect the off-normal condition when it occurs in the Depropanizer. All off-normal values and their time of occurrences would be automatically typed at some preset rate, such as once per minute, until they return to normal. As the upset progresses from the Depropanizer to the succeeding units, the scanner continues to sample every important variable; and when it deviates from accepted limits, prints the time and magnitude of the variable. This action continues until all points again return to normal, accepted limits. Except for the hourly record, no printing of normal data is done on the basis that "No news is good news." With data-handling equipment, we will be able to obtain our first accurate study of the inter-relation of multiple process units. Such studies will surely reveal the possibility of inter-process feedback loops that will permit us to attenuate disturbance waves before they reach the end product.

Optimalization, which is a tongue twister intended to define that much sought-after item, the self-adjusting controller, may be at hand. The controller settings (proportional, reset and derivative) that we use for a given set of conditions may be optimum for certain conditions, but may require changing for different loads. With an automatic data-handling system, we may be able to make time studies that will tell us the proper moment to change these functions and how much to change them.

Automatically obtained data will point the way to more efficient handling of storage facilities, possibly eliminate off-plot intermediate storage, and even reduce inner-plant storage. Not all the results of these new systems will necessarily be desirable. The reduction of storage facilities can result in the plant being run on an "all up or all down" basis. Trouble in one unit may require a complete plant shutdown.

Marketing—Accounting—Inventory Control

The marketing feedback loop has recently become a highly automated field; the wide acceptance of data-processing equipment has considerably reduced the time lags in this field. We find this type of automation becoming common in the accounting and time-keeping sections of most large refineries. Food and clothing stores are installing continuous inventorying equipment that automatically brings the inventory up-to-date the instant a sale is made. A large department store in Los Angeles has recently installed automatic sales and inventory-handling equipment. Instant sales and inventory data, coupled with current market reports and seasonal requirements, prove invaluable assistance to the Purchasing Department. The stock market in Canada recently installed an Automatic Memory Drum that instantly records the latest market prices and reads them out on demand from a telephone call. Several of the large petroleum corpora-

tions have adopted packs of punched cards instead of conventional credit cards. Although credit-card sales are only a percentage of total business, they are nevertheless a predictable part and constitute a valuable source of market information. The information is already in a form to be automatically fed back.

Our individual control systems have feedback loops and so does our over-all system. The operator obtains the information for adjusting set points from the laboratory analysis of product streams, and management analysis of market requirements. This information feedback is largely a manual operation at the present time. The chief operator receives a bulletin, note or conversation that tells him the data he needs to determine set points. In turn he passes this information to his subordinates in the same manner, and the required manipulations are carried out manually.

Product Analysis

Let us look at another slow human link, the laboratory (Fig. 2). Despite our pre-occupation with pressure, flow, temperature, etc., our real criterion of operation is the quality of the products. It is this quality that we are ultimately trying to control through a maze of dimly related process variables that we can measure conveniently.

Laboratory analysis has speeded up greatly during the past 10 years, but still constitutes an unacceptable delay for use as control feedback. A few years ago spectrographic instruments were introduced to the laboratory as a production tool, instead of the research tool they formerly were. More recently, they have been lifted out of the laboratory and are being applied as operating tools. Since that time great strides have been made with product composition analyzers such as infrared, ultraviolet, mass spectrometers, and refractometers, to mention a few. All are ultimately planned to analyze feed stocks and products to produce quality information automatically and rapidly. Here we have an important future trend. Development of continuous automatic stream analyzers is essential to the accomplishment of our goal.

Consider some of the possible benefits to be obtained from continuous feedstock analysis. We may be able to obtain a form of anticipatory control. Changes of feed composition could indicate new set points for our present types of controllers. The necessary changes could be made in each process unit at the appropriate time determined by the data-handling equipment. Optimalization may be achieved by computing new control mode settings from feed characteristics and process rates.

Product analysis is the logical basis for control in our campaign to raise the level of operating efficiency and quality of product. These analyzers must be continuous and capable of transmitting an acceptable signal to our data-handling equipment.

Improving existing equipment is a continuous trend. It follows many blind alleys and is guilty of being sidetracked by fads. To be consistent with our goal of an automatic plant, existing methods and equipment must be improved.

Electronic Control

Improved process efficiency demands improved control circuits. One of the factors in reducing off spec. and rerun time is the control-circuit response time. Plants are becoming physically larger. To comply with these demands, we have an established trend away from pneumatic controls, with their physical limitations, to electronic mechanisms with instantaneous electronic transmission of data.

This trend has important relationships with the other trends of automatic data handling, continuous stream analysis, and computer control. Fundamentally, all of these new developments are electronic devices and, for a satisfactory marriage of all of them at some future time, it is essential that they be compatible.

As is natural with new developments, we have tools available before we are capable of fully using them, or comprehending their full advantages. When we gain experience with these two new tools—data-handling equipment and continuous stream analyzers—the benefits to be gained from a computer-type master controller will become more evident. The petroleum plant of the future may well be as shown in Fig. 4.

Consider what is done in the aircraft field today with computer-type controllers. The flight plan is programmed into the controller. The plane is manually taken off the ground and, when safely in the air, the computer takes over. From this time until landing time, the controller receives various data from the plane and its navigational instruments, compares this data with the master plan and makes whatever changes are necessary to maintain the proper course. Our control problems are basically similar to those of aviation. We are at a disadvantage now because our knowledge of process time-constants is so meager. In a like manner in the processing industries, we will be able to formulate a processing schedule based on market prices and requirements, bring the plant on stream, and turn it over to the computer controller, which will continually analyze feed stocks, products and operating data. It will make corrections to keep the plant on schedule, and simultaneously handle accounting information until all requirements are met.

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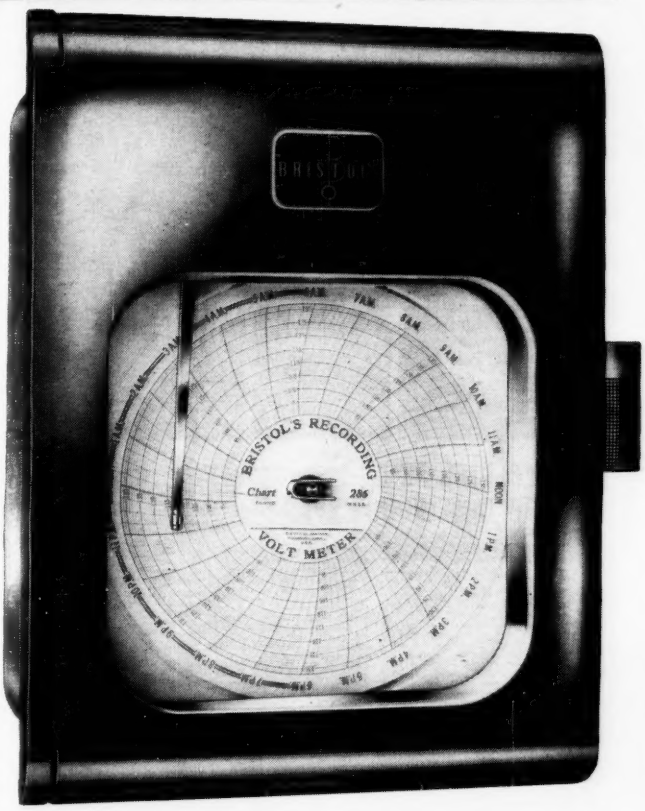

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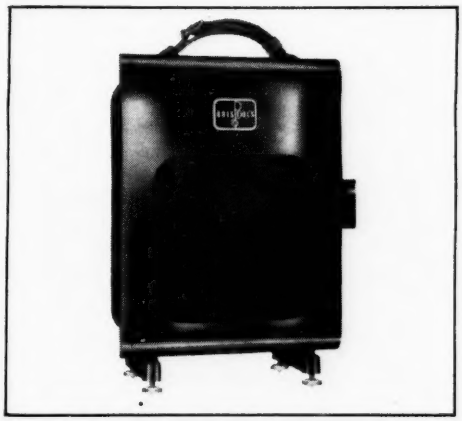
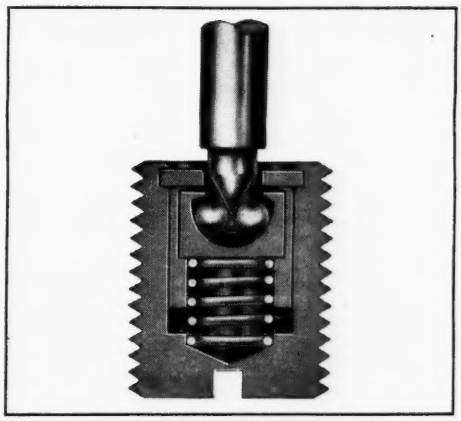
Models offered that comply with ASA Specification C39.2.

Want more facts? Write for Bulletin E1111 to the Bristol Company, 113 Bristol Road, Waterbury 20, Conn. 5.19



SINGLE AND TWO-PEN PORTABLE BRISTOL RECORDERS are offered in two models: one chiefly for portable pole mounting and the other for general portable service.



NEW BALL-BEARING SUSPENSION, loaded by a coil spring, prevents damage even under severe mechanical shock. Corrosion-resistant stainless steel ball bearings are almost tool-hard.

BRISTOL

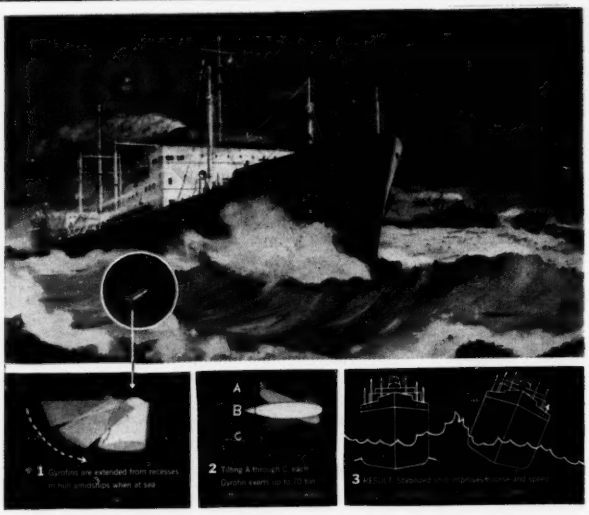
TRADE MARK BRISTOL'S REG U.S. PAT OFFICE

POINTS THE WAY IN HUMAN-ENGINEERED INSTRUMENTATION

AUTOMATIC CONTROLLING, RECORDING AND TELEMETERING INSTRUMENTS

For more information circle **63** on inquiry card.

PACE and Progress



FOLDING FINS TO TAME ROUGH SEAS

Stabilizer Cuts Ship's Roll Up to 90%

THE STORY BEHIND THE STORY

"Now I'd like to take a cruise more than ever!"

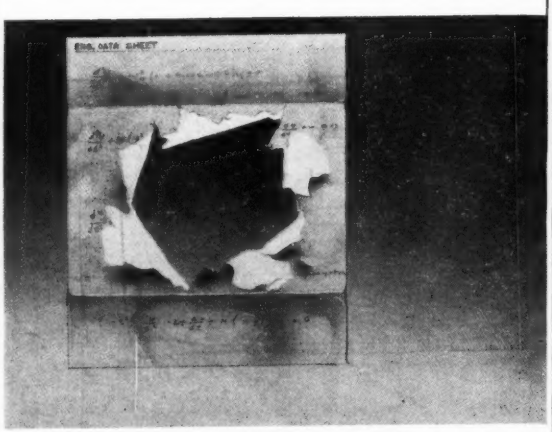
• That, probably, was the reaction of most people when radio, television and the nation's press announced recently an effective way of taming rough seas. But to shipowners and shipping men the announcement meant more than passenger comfort alone. It offered substantial savings – by reducing damage to ships and cargoes, by improving course and speed in heavy weather than saving fuel and time between ports.

• To understand how the Sperry Gyrofin* Ship Stabilizer is able to tame mountainous seas and eliminate up to 90% of the former roll, take another look at the illustrations above. The hydrofoil-type fins are constantly positioned to exert anti-roll forces of precision magnitude and timing. Controlled by sensing devices that anticipate each roll of the ship, one fin literally "pushes down" while the other "lifts up" – and even the biggest wave is subdued!

• In bringing this development to the maritime trade Sperry engaged the hydrodynamic experience and shipbuilding facilities of the Newport News Shipbuilding and Dry Dock Company. And many highly specialized Sperry skills were combined to make this development possible. The sensitive controls, for example, result from Sperry's vast experience in designing gyroscopic and electronic systems – the enormous power from Sperry's knowledge of hydraulic and servo systems.

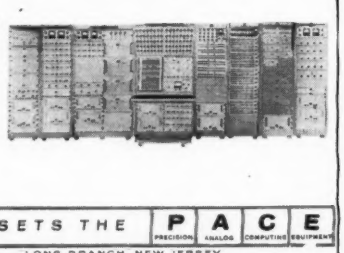
• These combined skills have also been responsible for many of our nation's most effective weapons of defense and for the most advanced instrumentations for ships of the sky and of the sea.

SPERRY GYROSCOPE COMPANY
Great Neck, New York
DIVISION OF SPERRY RAND CORPORATION



Break Through The PROBLEM Barrier

More and more engineers are turning first to Electronic Associates Analog Computing Groups to conquer the problem barrier. For in these Groups they find an unparalleled accuracy, reliability and flexibility that has been proved by thousands of operational hours. These groups feature a building block method that simplifies the economical expansion of the system by the addition of standard component groups. A complete Group and staff is available for your experimentation on a rental basis at Electronic Associates Computation Center just outside of Princeton, New Jersey. We will also gladly furnish details on our new line of high-speed sounds, problem checks, high accuracy Electronic Multipliers, Function Generators and precision output equipment. Write Dept. IA-8.



ELECTRONIC ASSOCIATES
EAI SETS THE P PRECISION A ANALOG C COMPUTING E EQUIPMENT
LONG BRANCH, NEW JERSEY

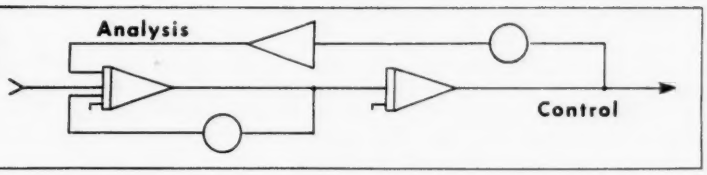
In the development of the Gyrofin* Ship Stabilizer, Sperry Gyroscope Company's Marine Division employed EAI's Precision Analog Computing Equipment—Equipment renowned for its unparalleled accuracy, reliability, and flexibility. One more example of two foremost companies working together to break the problem barrier through progressive engineering. Write Dept. IA-2 for details on Pace Equipment and the rental of time and equipment at the EAI Computation Center in Princeton, New Jersey.

*Sperry T. M.

ELECTRONIC ASSOCIATES Incorporated
EAI SETS THE P PRECISION A ANALOG C COMPUTING E EQUIPMENT
LONG BRANCH, NEW JERSEY

For more information circle **64** on inquiry card.

The SIMULATION COUNCIL Newsletter



John H. McLeod, Jr., EDITOR

Suzette McLeod, SECRETARY

1891 West Chapel Drive
Camarillo, Calif.

Western Simulation Council
Bill L. Waddell, Giannini DATEX Division, Pasadena, Calif.; Chairman, Steering Committee

Midwestern Simulation Council
R. R. Weber, Cincinnati Milling Machine Co., Cincinnati, Ohio; Chairman, Steering Committee.

Eastern Simulation Council
Frank Richmond, Glenn L. Martin Co., Baltimore, Md.; Chairman, Steering Committee

Southeastern Simulation Council
W. K. McGregor, ARO, Inc., Tullahoma, Tenn.; Chairman, Steering Committee.

Bits

Many of the more enlightened (ahem!) of those in the computer field have realized for some time that not only are there problems which can be more effectively handled by analog means, and other problems which can be more effectively handled by digital means, but that there are also problems which cry out for a combination of these techniques.

In the past there has been much talk and some action (your *Newsletter* has mentioned some work by *John Burke* and others at JPL), but to the best of our knowledge it has concerned particular operations or special problems (e.g., the use of a digital multiplier in an otherwise analog setup, or the use of an analog integrator in a special-purpose digital computer). Progress has been hampered by the fact that proponents of each technique have been so busy in their own backyard that they have not had the time, or in many cases the inclination, to look over the fence and recognize their neighbor's good points, much less build a style so they could get together. Furthermore, an extremely accurate and incredibly fast interpreter was needed before they could actually work together effectively, and analog-to-digital and digital-to-analog conversion equipment accurate enough and fast enough has not in the past been available.

For these reasons we believe that the work reported under PIECES this month, and similar work by others, presage the most important advance in Simulation since the development of the electronic differential analyzer. Read all about it!

Got no THOTS this month - - - - there are months like that!

Pieces

The Marriage of Figuresgalore

Sixty-five representatives of 21 organizations attended The Western Simulation Council meeting at the now fabulous Ramo-Wooldridge Corporation (see illustration) on Thursday afternoon, 12 January, and were treated to an explanation of what might seem to many to be more like a shotgun wedding of the Martins and the Coys than an opera.

Pfeffer Describes a Large-scale Problem

After *Norm Irvine* (Aerojet-General Corp., Azusa, Calif., and the retiring chairman) turned his job over to *Bill Waddell* (Giannini DATEX Div., Pasadena, Calif., and the new Chairman of the Steering Committee of the Western Simulation Council) *Irwin Pfeffer* (Ramo-Wooldridge Corp., Los Angeles, Calif.) got the discussion under way, saying that R-W has a very special large-scale simulation coming up in the very near future, in which they are going to try to tie their 300-amplifier Electronic Associates' analog computer and their Remington-Rand ERA 1103A digital computer together to perform a three-dimensional simulation of tremendous proportions—the simulation of a weapons system (under development at Ramo-Woold-

ridge) which will perhaps require all 300 analog amplifiers and the entire 1103A, operating (they hope) in real time. The EPSCO conversion equipment which they have on order is expected to do the tying, with 15 information channels in each direction. The requirements as to speed and accuracy are rather staggering.

Irwin referred to a block diagram which he had drawn on the greenboard. It showed that the missile is to be represented entirely by the analog computer. The simulation of autopilot, accelerometer, aerodynamics, and thrust characteristics will probably take about 200 amplifiers. The output of this section will be three components of missile body accelerations.

The kinematics of the system will be computed by the digital computer which will perform the necessary coordinate transformations and then solve the equations of motion by integrating the acceleration computed by the analog section. The three components of velocity and position thus made available are to be sent to the analog section on six of the information channels. In the actual system, missile velocities and positions are to be measured by a radar, which will also be simulated by the analog computer. Radar noise will be simulated by a noise generator and added to the velocity and position signals. The combinations will then be modified by the simulated radar dynamics to produce the analog of the velocity and position as measured by the radar.

The three components of velocity and three of position will be sent to the guidance computer, which is to be simulated by the 1103A. The guidance computer will first smooth the data (which has noise on it), then it will solve the guidance equations and generate commands. As there may be noise on the output calculations of the actual guidance computer, noise may have to be introduced in the simulation in a digital form.

In nature, kinematic equations are solved automatically and perfectly, so it will be necessary to do the best job possible on the digital computer. Therefore it is planned to solve these equations at least 100 times a second; perhaps 500 times a second.

Why Both Digital and Analog Techniques are Required

Dr. W. J. Schart (Convair-San Diego) asked, "Why do you do your kinematics on the digital computer?" to which Irwin replied, "Strictly because of the accuracy required. It is of the order of one part in 20,000 to 50,000."

Harold Gumbel (Naval Air Missile Test Center, Pt. Mugu, Calif.) remarked that it was not at all clear why they used an analog computer at all.

Pfeffer answered that to do the simulation entirely on the digital computer would increase the time required to make small changes in the missile dynamics many-fold and would increase the complexity of the program on the digital computer enormously.

"In other words," Gumbel interpreted, "You set the system simulation this way because you intend to use the analog computer to design those characteristics of the system which it represents."

Irwin said this was true to some extent. They intend to vary some of the parameters, and this can be done easily and quickly on the analog computer. But another reason is to reduce the complexity of the over-all simulation. The time factor would be more than doubled and might be increased perhaps five times if the entire simulation were done digitally. The combined simulation uses about twice as much equipment but might reduce the time by a factor of 5.

William Schroeder (Lockheed Aircraft, Burbank, Calif.) asked, "Why is it desirable to simulate in real time?"

To this Irwin replied, "We don't know that we can. We hope to, but we might have to slow the problem down." One reason they wish to operate in real time is that it may be necessary to make quite a number of noise runs. Many hundreds of solutions may be required for any one statistical point.

Irwin was asked what sort of accuracy they expect to get from the acceleration measurement. "What is the validity of starting with a rough input and carrying out the computation with extreme accuracy?" To this cogent question, which has probably bothered all of us at times, Irwin gave the clearest answer we have heard. "The missile itself will be an analog device. Any accelerometer which might be in it is not likely to be more accurate as a piece of hardware than its representation on the analog computer. But the system will work in such a manner that even though the accelerometer may be no better than one part in several hundred, the actual accuracy that can be achieved by the guidance computer will be considerably better than that. So the analog computer will be used to represent the missile, while the digital computer will be used to represent the guidance computer. By hooking them up in this way, we will be able to actually simulate the accuracies of the system."

Hans Meissinger (Hughes Aircraft Co., Culver City, Calif.) offered one more comment on accuracy which may be achieved by using digital for kinematics and analog for dynamics. "In kinematics you often have to subtract large numbers to get small numbers. This operation must be per-

DON'T ASK ME HOW TO BUILD A MISSILE! IT WAS YOUR BID THE NAVY ACCEPTED!

formed with extreme accuracy if the result is to be even reasonably accurate. This is difficult with analog —easy with digital."

Norm Irvine asked, "Is there a reason for doing the data-smoothing in a digital form? Wouldn't there be a lot gained by doing the smoothing on the other side of the converter?"

Pfeffer answered, "This is just the first way we thought of doing it. We may change."

Jack Sherman (Lockheed Aircraft Corp., Van Nuys, Calif.) asked, "Aren't you going to be performing some of your calculations twice? For example, to find your missile body accelerations won't you have to get your missile body velocities and positions in analog form first?"

Irwin agreed, saying that yes, there will be a repetition of missile position and missile velocity in both the analog and digital machines, but that they will not be fed over.

"That's what I mean; you will be computing this on two different machines," Jack said. "Are you going to have any cross-comparison?"

Irwin replied, "A good point. We might have." And then got a laugh by adding doubtfully, "If we have any channels left over."

Gumbel observed, "The answer is No!"

Irwin returned to the subject of computing times. "The analog computer is by nature a real-time device, so there is no problem there. But some of the digital calculations have to be performed at the rate of hundreds of times per second. We believe that this will be possible if we use a great care in programming and if the conversion equipment is so fast that it doesn't impose any additional delay on the system."

Programming With a Converter Clock

Irwin showed a diagram to illustrate what he meant by "care in programming." The principle may be explained by assuming that there are some computations, for instance the kinematics, which the digital computer must repeat at a very fast rate, which we may assume to be 100 times per second. Call these the "A" computations. Other computations, like those of the guidance computer, may not be required so often, perhaps 50 times per second. Call these the "B" computations. Then some miscellaneous "C" computations may be required still less often, perhaps 25 times per second.

The read-in of analog information to the digital computer and the presentation of digital results to the analog computer by the conversion equipment, and to some extent the operation of the digital computer, are controlled by the converter clock, which in this example would be adjusted to produce 100 control pulses per sec.

On the first converter clock pulse of a cycle, all data from the converter will be read into the digital computer, which will proceed with all of the A_1 computations, part of the B_1 computations, and perhaps part of the C_1 computations. On the next clock pulse the results of the A_1 computations will be presented to the converter for conversion to analog signals, and all of the converted analog data will be read into the digital computer, which will make an A_2 computation and then proceed to complete the B_1 and perhaps do some more of the C_1 computations. On the next clock pulse A_2 and B_1 results are presented for conversion, the necessary data are read into the digital computer, and A_3, the first part of B_2, and perhaps some more of C_1 are computed. Following the next pulse the computations of A_4, B_2, and C_1 are all completed and the four-pulse cycle is repeated.

The program is fairly tricky and involves using the interrupt feature of the 1103A. In order to achieve the required speed, reading and writing times must be held down to hundreds of microseconds at the most. Actually the specs require that the conversion itself take place in the order of 100 microseconds. Slow conversion would seriously hamper the 1103A.

George West (Ramo-Wooldridge) pointed out that the interrupt feature of the 1103A was such that it was not necessary to pad (allow "slop-over" time) before each clock pulse but only at the end of a complete cycle. The longest time for any digital operation is 400 microseconds (for division) so if you happened to cut in at the beginning of such an operation you would have to wait until the instruction was completed. But there is no such uncertainty as to the time of sampling because that is controlled by the clock pulse.

Low on the EPSCO Conversion Equipment

After this system explanation by Pfeffer, *Henry Low* (Ramo-Wooldridge) took over to explain in some detail the operation of the EPSCO* conversion equipment which they expect to get. The electronic details are beyond the scope of this *Newsletter**, but roughly the system consists of an absolute-value circuit, a comparator, a digital-to-analog converter, and a programmer. An analog signal ranging between −100 and +100 v is converted by the absolute-value circuit and compared to a converted digital value in the middle of the comparator range to determine the most significant digit of a 17-digit binary number. Depending on this digit, the analog voltage is next compared with another value in the middle of the remaining range interval to determine the next digit. This process is repeated until the analog voltage is digitalized to 17 places plus sign. Specifications require that the comparator be accurate to within 0.1% of full scale, or 1 millivolt, whichever is greater, and have a dynamic range of 1 to 100,000.

Henry showed schematic electronic diagrams of the absolute-value circuit, the comparator, and the digital-to-analog converter, which caused a good bit of comment. In fact, in one amusing case *Bob Leger* (Convair) pointed out that a circuit would not work because it showed equal positive and negative feedback around an amplifier. Henry had sketched the circuits on an overgrown tablet, and when he wondered out loud "How do I get out of this?", someone brought down the house by suggesting "Turn the page!".**

After Henry turned the page and explained everything else to everyone's apparent satisfaction, *Bill Waddell* asked for questions in general.

Norm Irvine observed that they expect to compute the kinematics approximately 100 times a second. "This implies that you are thinking in terms of 50-cps information."

Henry answered, "About 30. This conversion equipment is really about the peak of the state of the art—many vendors wouldn't even touch our specifications." Then turning to Bill Waddell—"That right?"

Bill's enthusiastic "Absolutely true" drew understanding laughter.

Dov Abramis (Convair-Pomona) wanted to know when they expected

*588 Commonwealth Avenue, Boston 15, Mass.

* i.e., over your Ed's head.

** Once your Ed. asked someone who should know how EPSCO accomplished the feats of conversion which they claim, and was told "They ain't sayin' ". Couldn't be they purposely threw Henry a curve!?

Ramo-Wooldridge analog-computing facility features air-conditioning, engineered lighting, sound-absorbent ceiling, draperies—and 300 new EA amplifiers plus associated equipment.

the equipment, and was told some time in October.

Stan Rogers said they would have similar equipment delivered to Convair-San Diego in about two months, so he suspects that they will know before others how some of the things discussed will work.

McLeod wanted to know if anybody had seen any equipment which would meet these specifications actually in operation anywhere.

Henry said he had seen some devices that worked at much lower speed (laughter), and that *Bob Bennett* (Ramo-Wooldridge) had talked to someone at Lincoln Labs who has a device which is *very* fast, but that when he and Irwin Pfeffer were back there they tried to get to see it but couldn't even get into the lab (more laughs). There is one channel, he added, which is slated to go to Shell Development (Emeryville, Calif.). They don't have it yet. It isn't working yet. But they have been invited to go back to Boston to see it work!

Meissinger asked about the data-smoothing on the analog side, and was told that it will be left as a series of step functions.

Sherman asked Henry if he could describe the digital-to-analog smoothing circuit.

Henry explained that the current sources furnishing the analog voltages were pulsed on or off and would stay that way until new information came in.

Returning to the subject of actual hardware actually working, *Jim Murrin* (J. B. Rea Co., Santa Monica, Calif.) said he didn't want to sound as if he was advertising, but that J. B. Rea has two devices operating in the field at the moment, and a third on the floor which isn't yet complete, but which should be ready for rent about the middle of February. The unit is on a par with the EPSCO equipment in many respects. It has been operating at 10,000 samples per second, but this rate can be stepped up to 100,000.

S. I. Klein (National Cash Register) asked whether or not they thought the 1103A would keep up with the converter.

Irwin passed the question to *George West*, who said that they didn't know because all of the equations are not yet written in final form. "Certainly if you should run all of the channels wide open to send numbers to the 1103A, it couldn't do much except perhaps add them and send them back. There would not be very much time to do computing. Running in true time will depend on how many computations have to be made at the fast sampling rate, how many at the slower rate. These questions are not yet answered. We will be able to make a good guess after some more experience with a current all-digital simulation problem."

About that time Irwin broke up the discussion by announcing that coffee and cookies awaited outside.

* * *

Coffee, Cookies—and R-W

After the coffee and cookies and the always-pleasant meeting with old and new friends during the break, we were shown into the (almost literally) plush R-W analog computing facility. The extent to which they have gone to provide ideal working conditions is far beyond anything we have seen so far: Separate air-conditioning systems for the room and the equipment; excellently engineered lighting; sound-absorbing material on the ceilings, and draperies completely covering all walls.

Oh yes, and the computing equipment! About 300 new EA amplifiers and associated equipment arranged in the form of 3 L's* backing three corners of the room. (S'matter with that other corner, boys? Let's not be chintzy.)

Well, we thought that was the grandest till we walked next door to see the 1103A and were dismayed to find deep wall-to-wall carpeting there! However, we felt better when Jack Sherman explained that digital equipment has a way of dropping digits and, as digits are fragile, the carpet was to prevent any breakage.

*One of the L's was straightened out for the picture at the top of this page.

Information (Without Theory)

We have a letter from *Gomer L. Davies*, President of the Davies Laboratories, 4705 Queensbury Road, Riverdale, Maryland, enclosing information on their Magnetic Tape Time-Delay Simulator (Dead Time Simulator) which sounds as if it might be a handy gadget to have around. But Gomer (perhaps pointedly) mentions no price, so "Quien sabe"?

Basically the equipment consists of a tape mechanism servo-driven at a speed proportional to one input signal while another signal is pulse-width modulated and recorded on the tape to be played back subsequently and demodulated to give a voltage varying ± 1 v from 5 volts, the variation being proportional (within 1%) to the original signal and delayed by from 1 to 10 seconds (or with additional equipment up to 2 minutes).

We also have a letter from *Everett T. Sprague*, Business Manager of Control Specialists, Inc., 115 E. Arbor Vitae, Inglewood, Calif., telling us of their Desk Model Analog Computer "designed primarily for equipment simulation and the solution of linear differential equations, but capable of simulating certain nonlinearities, (such as threshold and hysteresis) often found in physical systems."

* * *

If you want more info, we urge that you read "What Automation Means to America" by Carroll W. Boyce in *Factory*, September 1955, because this is the most lucid article we have read on "why industry *must* automate." And if you wonder why this *Newsletter* is concerned with automation, we will point out that the same computer techniques which make possible simulation as we practice it today also make the difference between mechanization and automation.

Computer Events

Other events on page 318

You Are Invited

The Chairmen of the various Simulation Councils often receive letters from men who want to come to the Council meetings, and who ask permission to do so. This is not necessary. The Councils are informal groups; all who wish to come may do so at any time; no advance permission is required. Anybody interested in simulation technique is not only cordially invited to attend any of the Simulation Council Meetings but is urged to do so. We need your thoughts. To help you know what to expect, some brief program notes will be included in each calendar item in the future.

Western Simulation Council

Date: 8 March 1956

Place: Firestone Tire and Rubber Company, Guided Missile Division, 2525 Firestone Boulevard, Los Angeles, Calif.

Subj: Electro-mechanical (servo) vs. electronic multiplication—resolution—function generation.

Clearance: No clearance will be required for the discussion part of the meeting, but Security Clearance of Confidential will be required for the tour of missile facility which will follow.

Midwestern Simulation Council

Date: 19 March 1956

Place: Cincinnati Milling Machine Company, Cincinnati 9, Ohio.

Subject: "Mathematical Formulation and Transfer Functions"; Tentative speakers: Larrowe (University of Michigan); Hamer (Electronic Associates); Robinson (Wright Air Development Center)
Discussion will emphasize (1) Mathematical formulation or direct formulation? (2) How to set up transfer function most effectively? (3) Are you simulating or computing?

Eastern Simulation Council

Date: March 23, 1956

Place: Waldorf-Astoria Hotel—New York City

Host: Mid-Century Instrumatic

Subject: Function Generation

INSTRUMENTS and AUTOMATION Books

Introduction to Process Control System Design, by A. J. Young. 1955. Instruments Publishing Co., 845 Ridge Ave., Pittsburgh 12, Pa. 378 p. $6. 8¾ in. Presents fundamentals of process control, using the frequency response approach. Employs a minimum of mathematics.

Progress in Low Temperature Physics, edited by C. J. Gorter. v. 1. 1955. Interscience Publishers, New York 1, N. Y. 418 p. $8.75 9¼ in. Reviews recent research and the present knowledge in several fields of low-temperature physics. Special attention to magnetism, liquid helium and superconductivity.

Handbook of Scientific Instruments and Apparatus, 1954. Published in Connection with the 38th Physical Society Exhibition. 1954. Physical Society, 1 Lowther Gardens, Prince Consort Rd., London S.W.7, England. 201+76 p., unbound. £2 10s., postage 1s. 6d. Presents descriptions of products of 103 exhibitors; 76 pages of advertising.

Transistor Electronics, by Arthur W. Lo *and others.* 1955. Prentice-Hall, New York 11, N. Y. 521 p. $12. 8½ in. Theory and practice of transistors and transistor circuits. For advanced undergraduate or graduate students of electrical engineering, and electronics engineers.

Verbindungselemente der Feinwerktechnik, by Herman Pöschl. 1954. Springer-Verlag, Berlin. 108 p., unbound. DM 13.50.9 in. Comprehensive treatment, very fully illustrated.

Introduction to Automatic Computers; a Systems Approach for Business, by Ned Chapin. c1955. Technology Center, Chicago 16, Ill. 245 p., unbound. $9. 11½ in. Rather non-technical explanation of characteristics of electronic digital computers, and their financial justification in business. Reproduced from typewritten copy.

Electronic Measuring Instruments, by E. H. W. Banner. 1955. Macmillan Co., New York 11, N. Y. 395 p. $8.50. 9 in. Survey of electronic measurement for very high and very low values, for remote indication, and for increased accuracy. Intended for the instrument engineer, the user of instruments, and the student with some knowledge of electronics.

Regelungstechnik; Vorträge des VDI/VDE-Lehrgañges in Bonn 1953 and Esseñ 1954. 1954. Deutscher Ingenieur-Verlag GMBH, Düsseldorf 10, Germany. 282 p. 24 DM. 9½ in. Papers on principles of control, control techniques, and control in various industries.

Proceedings of the First Conference on Training Personnel for the Computing Machine Field, edited by Arrid W. Jacobson. 1955. Wayne Univ. Press, Detroit 1, Mich. 104 p. 9¼ in. Papers considering the educational and manpower problems brought about by the automatic computer.

Tables of Circular and Hyperbolic Sines and Cosines for Radian Arguments. Ed. 3, 1953. National Bureau of Standards. U. S. Government Printing Office, Washington 25, D. C. 407 p. $3. 10½ in. (Applied Mathematics Series, no. 36.) In this edition, a conversion table has been extended to express degrees, minutes and seconds in terms of radians to 10 decimal places.

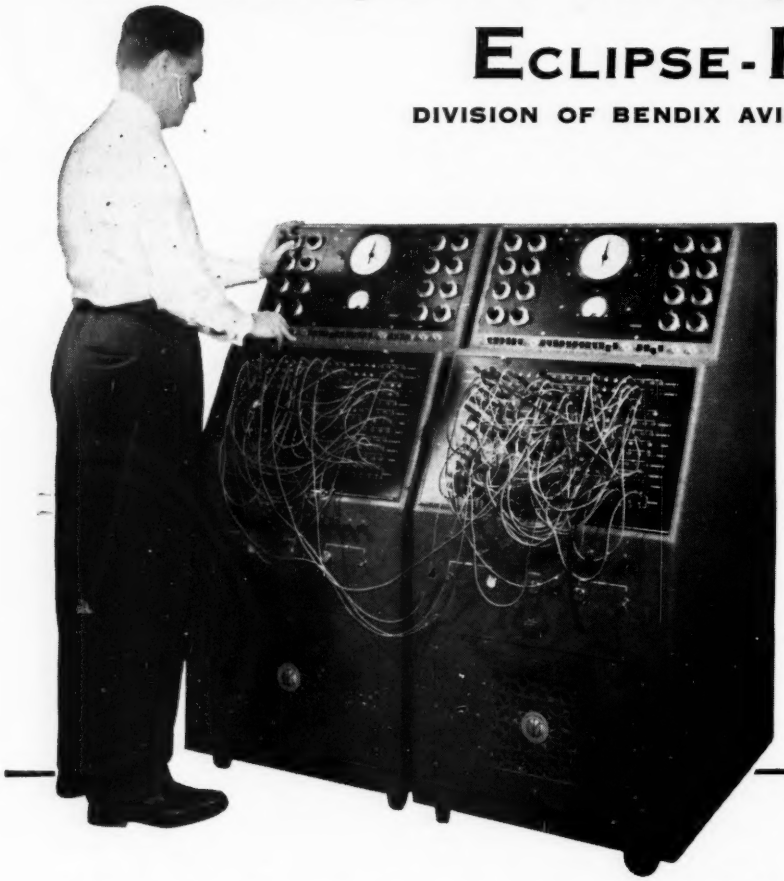
Basic Synchros and Servomechanisms, by Van Valkenburgh, Nooger & Neville, Inc. 2 v. c1955. John F. Rider, New York 13, N. Y. 137+121 p., unbound. $5 ($2.75 each). 9 in. "The text of this—course, as currently taught at Navy specialty schools, has now been released for civilian use." Features large pictures on elements and fundamentals.

Mathematics of Engineering Systems (Linear and Non-linear), by Derek F. Lawden. [1954.] John Wiley & Sons, New York 16, N. Y. 380 p. $5.75. 9 in. Presents a number of mathematical methods which may be used to analyze the behavior of various "physical systems" such as electronic amplifiers and oscillators, electric circuits, servomechanisms and regulators.

Mid-Century's MC-400 Computers Star at

ECLIPSE-PIONEER

DIVISION OF BENDIX AVIATION CORPORATION



Because they are ideal, low-cost laboratory tools!

These small, compact computers were especially designed to meet the requirements of a desk-side computer, training device, dynamic tester, laboratory tool, or as a building block which may be either expanded or appended to other equipment. And, they have all of the quality, amplifier precision and power supply to make them equal to and, in some cases, better than the larger machines now available.

The MC-400 Portable Computer contains:

- Six Integrating-Summing chopper stabilized amplifiers.
- Six chopper stabilized summing amplifiers.
- Two amplifier driven relays.
- Sixteen scale factor potentiometers.
- One multiplying servo with indicator dial.
- Four diode limiters.
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For more information circle **65** on inquiry card.

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Here is why Crossbar takes the place of Relay Tree in your automation vocabulary: With the Kellogg Crossbar several switching operations can be carried on independently at the same time . . . entire switch can be mounted in drawer-type frame for easy inspection . . . contact material is palladium (or gold) . . . any crosspoint can be activated in less than 50 milliseconds.

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Kellogg Crossbar:

- Requires practically no routine maintenance
- Is equivalent to a bank of relays, assembled, mounted, and partially prewired
- Uses less hardware
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ADAPTABILITY

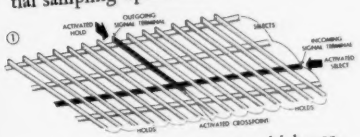
Kellogg Crossbar has been adapted to a wide variety of industrial applications.

ENGINEERING HELPS

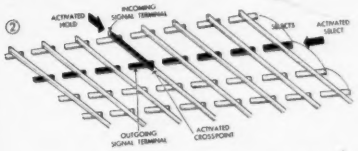
Kellogg engineers will show you how Crossbar advantages will work for you. Saves design time.

crossbar (krôs'bär")

The most modern, compact, fast, and economical means of concentrating hundreds of relay or switching operations for practically any automatic control, computing, reporting or sequential sampling operation.



The basic Crossbar principle which permits any of several incoming circuits to be connected to any of several output circuits is illustrated above. This switch actually can connect any of 60 circuits, 3 at a time, to any of 75.



The drawing above shows a means of switching one incoming circuit to many possible outgoing circuits. This type of switch can easily be adapted to switch one circuit to as many as 936 circuits.

cross-bill (krôs'bil") n. any of several species of finch having curved mandibles whose points cross each other.

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For more information circle **66** on inquiry card.

INSTRUMENTS and AUTOMATION Events

For other computer Events see page 335.

February 27-29

Symposium on Microwave Crystal Rectifiers & Their Applications, sponsored by Asst. Secy. of Defense, Advisory Group on Electron Tubes, Hexacon Bldg., Signal Corps Engineering Labs, Ft. Monmouth, N. J. For information contact W. G. Matthei, Evans Signal Lab., Belmar, N. J.

February 27—March 2

Seventh Annual Pittsburgh Conference on Analytical Chemistry and Applied Spectroscopy, Wm. Penn Hotel, Pgh., Pa. For information contact Dr. Fritz Will, Box 1353, Pittsburgh 30, Penna.

February 28-29

Scintillation Counter Symposium, sponsored by the IRE and AIEE, Shoreham Hotel, Washington, D. C.

March 2-3

Third Annual Cleveland Electronics Conference, Western Reserve University, Old Gymnasium, Cleveland, Ohio.

March 5-7

Sixth Conference on Instrumentation in the Iron & Steel Industry, Hotel Webster Hall, Civic Center, Pittsburgh, Pa. For information contact Richard Rimbach Associates, 845 Ridge Ave., Pgh 12, Pa.

March 15-16

Fifth Annual Spring Conference of American Institute of Industrial Engineers. For information write W. S. Ritchie, Rm. 330, Cuyahoga Savings Bldg., 2123 E. 9th St., Cleveland 15, Ohio.

March 18-24

Consecutive Meetings and Co-Exhibit of American Congress on Surveying and Mapping and the American Society of Photogrammetry, Shoreham Hotel, Washington, D. C. For information write ACSM-ASP, Box 470, Washington 4, D. C.

March 19-22

IRE National Convention & Radio Engineering Show, Waldorf-Astoria Hotel and Kingsbridge Armory and Palace, New York, N. Y. For information contact Wm. A. Copp, IRE, 1475 Broadway, New York 36, N. Y.

March 19-29

Ninth annual short course in Quality Control by Statistical Methods, College of Engineering, University of Illinois. For further information write to Professor John A. Henry, Mechanical Engineering Laboratory, University of Illinois, Urbana, Illinois.

March 26-27

ASM Instruments & Regulators Conference, Princeton University, Princeton, N. J.

April 1-5

Oil and Gas Power Conference sponsored by American Society of Mechanical Engineers, Hotel Jung, New Orleans, Louisiana.

April 3

Annual Symposium of the New Jersey Section, Inc. of the Instrument Society of America, Essex House, Newark, N. J.

April 5-6

Special Technical Conference on Magnetic Amplifiers, cosponsored by AIEE Committee on Magnetic Amplifiers, IRE Professional Group on Industrial Electronics and ISA Central New York Sec., Hotel Syracuse, Syracuse, N. Y. For information write Charles F. Spitzer, General Electric Co., Bldg. 3, Electronics Park, Syracuse, N. Y.

April 10-12

12th Annual Meeting and Metal Powder Show, Hotel Cleveland, Cleveland, Ohio.

April 11-13

1956 IRE 7th Region Technical Conference, Hotel Utah, Salt Lake City, Utah.

April 9-22

International Exhibition on Instrumentation-Automation, Oslo, Norway, sponsored by the Norwegian Industries Development Association (SNI) and Royal Norwegian Council for Scientific and Industrial Research (NTNF). For information write Studieselskapet for Norsk Industri, Munkedamsveien 53 B, Oslo, Norway.

April 10-11

Machine Design Conference, sponsored by the American Society of Mechanical Engineers, Bancroft Hotel, Worcester, Mass.

April 10-11

Symposium for Management on Applications of Analog Computers, Sponsored by Midwest Research Institute in cooperation with technical societies, Hotel Phillips, Kansas City, Missouri. For information write MRI, 425 Volker Blvd., Kansas City 10, Mo.

April 13-14

Tenth Annual Spring Television Conference sponsored by the Cincinnati Section of the Institute of Radio Engineers will be held at the Engineering Society of Cincinnati Building, 1349 E. McMillan St., Cincinnati, Ohio. For information write Reuben Nathan, Crosley Div., Avco Mfg. Corp., Glendale-Milford Rd., Evendale, Ohio.

April 16-17

Gas Turbine Power Conference, sponsored by the American Society of Mechanical Engineers, Hotel Statler, Washington, D. C.

April 19-20

Science Section of the Environmental Equipment Institute, Sheraton Hotel, Chicago, Ill. For information write H. F. Sander c/o Vapor Heating Corp., 6420 W. Howard St., Chicago, Ill.

April 25-27

Symposium on Nonlinear Circuit Analyses II, Engrg. Societies Bldg., 33 W. 39th St., New York, N. Y., sponsored by Microwave Research Institute of the Polytechnic Institute of Brooklyn.

April 25

Symposium on "Control Systems Engineering—Electronic Controls In Industry" sponsored by the Wilmington Section, ISA. For information contact W. G. Schmick, Minneapolis-Honeywell Regulator Co., Orange St., Wilmington, Del.

April 26-27

Technical Conference on Electrical Recording and Controlling Instruments sponsored by AIEE, ASME and ISA cooperating, to be held at the Hotel Bradford, Boston, Mass. For information contact E. T. Davis, Leeds & Northrup Co., 4901 Stenton Ave., Philadelphia, Pa.

May 1-3

Electronic Components Symposium at the Auditorium of the U. S. Dept of Interior, Washington, D. C. For information write A. W. Rogers, Chairman, Signal Corps, Ft. Monmouth, N. J.

May 6-9
2nd National Flight Test Instrumentation Symposium sponsored by North Texas Section ISA & Flight Test Instrumentation Sub-Committee, Fort Worth, Texas.

May 8-11
Metals Engineering-AWS Conference sponsored by the American Society of Mechanical Engineers, Hotel Statler, Buffalo, N. Y.

May 14-16
8th Annual National Conference on Aeronautical Electronics, sponsored by the IRE, Dayton Biltmore Hotel, Dayton, Ohio. For information write P. O. Box 621, Far Hills Br., Dayton 9, Ohio.

May 14-17
Design Engineering Show, Convention Hall, Philadalphia, Pa. For information write Clapp & Poliak, 341 Madison Ave., New York, N. Y.

May 14-17
The Physical Society 40th Exhibition of Scientific Instruments and Apparatus, Royal Horticultural Society's Halls at Westminster. For information write Exhibition Secretary, 1, Lowther Gardens, Prince Consort Rd., London, S.W. 7, England.

May 17-18
7th Annual Conference on Fundamentals, Current Practice and Recent Advances in Industrial Engineering, Shoreham Hotel, Washington, D. C. For information write American Institute of Industrial Engineers, 145 N. High St., Columbus 15, Ohio.

May 14-19
International Colloquim on Spectroscopy, 6th annual meeting to be held at Amsterdam, Netherlands. Persons wishing to attend or contribute should correspond with the Secretary, Colloquim Spectroscopicum Internationale, Laboratorium voor Analytische Chemie, 125 Nieuwe Achtergracht, Amsterdam-C4, Netherlands.

May 21-24
Electronic Parts Distributors Show at the Conrad Hilton Hotel, Chicago, Ill. For information write S. I. Neiman, EPDIN, La Salle St., Chicago 2, Ill.

June 6-8
American Society for Quality Control 10th Annual Convention and Exhibit, Palais Du Commerce, Montreal, Canada. For information write Charles R. Kendel, Lamson & Sessions Co., 1971 West 85th St., Cleveland 2, Ohio.

November 26-30
Third International Automation Exposition, New York Trade Show Building, 500 8th Ave., New York, N. Y. For information write Richard Rimbach Associates, 845 Ridge Ave., Pittsburgh 12, Penna.

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MAXIMUM OUTPUT TORQUE—from 50 inch ounces to 150 inch ounces.

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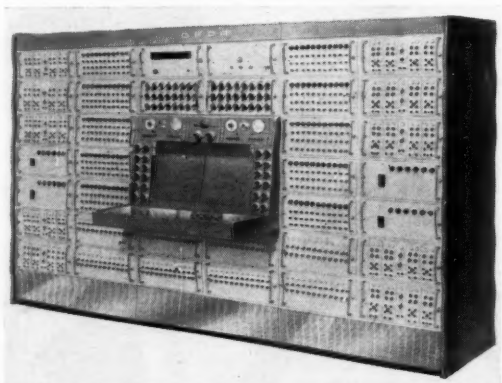
For more information circle **67** on inquiry card.

INSTRUMENTS and AUTOMATION — New Instruments

COMPUTING, DATA PROCESSING

Scoop Announcement

A14 GEDA COMPUTER

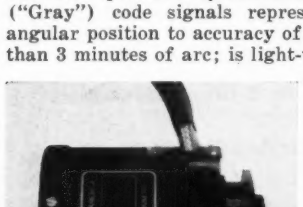


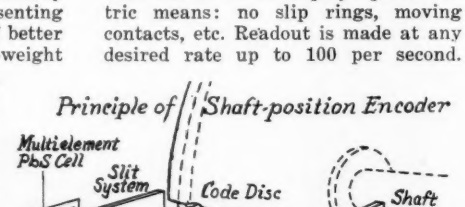
New "A14 GEDA," a unitized expansible general-purpose computer embodies latest advances in function generation and analog computation, and combines the features of the "L3 Linear" and "N3 Nonlinear GEDAs" into an expansible general-purpose unit with from 12 to hundreds of amplifiers. Features include (1) units to meet individual requirements with facilities for economic expansion, (2) linear equipment said to be "the most precise, widest bandwidth available," (3) large selection of nonlinear elements, (4) electronic multiplier said to be "most precise in the industry," (5) stable electronic function generation, (6) all-electronic map reader, (7) precision electronic resolver—an industry "first," (8) built-in automatic problem analyzer, (9) automatic range detector for scaling, (10) automatic readout printing to check connections and scale factors, (11) provision for both mathematical and simulation techniques—another "first," (12) automatic dialing system for selecting scale factors and variables—another "first."—*Goodyear Aircraft Corp.*, 1210 *Massillon Rd., Akron* 15, *Ohio.*

For more information circle **201** on inquiry card.

OPTICAL SHAFT-ANGLE DIGITIZING SYSTEM

New optical-type analog-to-digital converter provides cyclical-binary ("Gray") code signals representing angular position to accuracy of better than 3 minutes of arc; is light-weight (3.8 lb) and operating torque is less than 0.2 oz-in. It employs photoelectric means: no slip rings, moving contacts, etc. Readout is made at any desired rate up to 100 per second.





Among features: (1) Pencil-shaped high-intensity gas-discharge-lamp whose flash duration is about 50 usec; flashes are triggered at desired rate by 15-v 2-usec pulses. (2) Shaft can be rotating as fast as 150 rpm and still give full-accuracy readings of position at any instant. (3) Output of photocell array is raised to level of 1.5 to 3 v at 3000 ohms by built-in potted transistorized preamplifiers.—*Electronics Corp. of America, Cambridge* 42, *Mass.*

For more information circle **202** on inquiry card.

D-C ANALOG COMPUTER

New d-c analog computer, though of comparatively low cost, features several "firsts," among them a unique

problem board whereby it can be operated by average office personnel; for example setting up a problem of simple oscillation requires, instead of hooking up 50 cables and 100 connections (as on most computers), positioning four switches and four dials. Another "first" is that new computer can operate on both "real" and "fast" time wherein monitoring can be held instantaneously at any point, then resumed without breaking sequence.—*Weber Electronics Div.*, 2820 *Ontario Street, Burbank, Calif.*

For more information circle **203** on inquiry card.

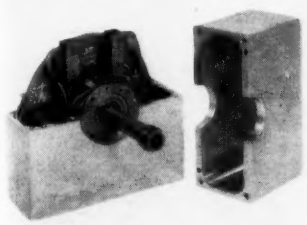
CONTENTS OF THIS DEPARTMENT

Amplifiers	339	Inspection and Gaging	324
Aviation, etc.	319	Laboratory	321
Computing, Data Processing, etc.	310	Mechanical Components	348
Counting	318	Mechanical Testing	328
Electrical Instruments	332	Miscellaneous	350
Electr-Instrument Accessories	337	Nucleonics	320
Electrical Testing	332	Optics	323
Electrical Components	342	Power Supplies	341
Electromechanical Components	344	Process Control	312
		Shop Equipment	324
		Speed Meas't and Control	320

FOR FURTHER INFORMATION use the postage-free order card on page 387.

SHAFT-ANGLE ENCODERS

New "Angular Position Coding Systems" convert shaft angles into digital outputs; are available in two



types: (1) non-ambiguous coded type which can be read-out on demand "on the fly" or at static shaft positions; (2) incremental coded type which registers instantaneous postion of shaft and each incremental change, latter available with driving torque as low as 0.01 oz-in and moment of inertia as low as 10 g-cm^2.—*Wang Laboratories, Inc., 37 Hurley Street, Cambridge* 41, *Mass.*

For more information circle **204** on inquiry card.

DUAL SERVO MULTIPLIER

New "GN215-N3J" comprises two independent servo multiplying systems each capable of providing three products as outputs; is designed to furnish "GEDA" computer users with a greater computing capacity in frequent cases where not more than three products per shaft are required.—*Dept.* 937, *Goodyear Aircraft Corp., Akron* 15, *Ohio.*

For more information circle **205** on inquiry card.

OPTICAL SHAFT-ANGLE DIGITIZING SYSTEM

New optical-type analog-to-digital converter provides binary-parallel code signals representing angular position to accuracy of better than 10 seconds of arc. Shaft angles are sampled at rates up to 60 per second. Heart of system is 8½"-diam glass disc on which code pattern is engraved photographically to divide one rotation of shaft into 65,536 (2^{16}) discrete steps whose boundaries are accurate to 8 parts per million in relation to one another. To take advantage of disc's own extraordinary precision, system embodies refinements, among them: (1) Shaft bearings are said to have "a radial accuracy better than a small fraction of a basic increment of disc." (2) Width of readout slit is 196.8 microinches and is uniform. (3) An extra phototransistor in reading head scans a clear zone on disc to provide light-intensity reference for automatic compensation in event of changes of flash-lamp intensity.—*Encoder Div., The Baldwin Piano Co.,* 1818 *Gilbert Ave., Cincinnati* 2, *Ohio.*

For more information circle **206** on inquiry card.

FOUND-

the MISSING LINK in electronic control... the electro-hydraulic FINAL CONTROL element

NEW ASKANIA

ELECTRO-HYDRAULIC VALVE ACTUATOR

IS CONTINUOUS-ACTING, DEPENDABLE

• Here's a new valve actuator which makes remote *electrical operation of the final control element* a reality for the first time. Adaptable to practically all electronic controllers, it produces an accurate, dependable heavy duty action capable of delivering a 600 lb. thrust to slide stem valves up to 8 inch size. Relays and positioners are eliminated because the actuator connects directly to the controller.

SIMPLE OPERATION... EASY MAINTENANCE

• Operation of the Askania **"EHVA"** is automatic. Maintenance is less because there are no compressors, dehumidifiers, filters or piping to create trouble.

Trouble sources are greatly minimized... failures seldom encountered...easy to locate and rectify.

ELIMINATES WEATHER FACTOR

• Electrical operation means no inconvenience or failure from condensation or freezing. Trouble free operation under any conditions... indoors or out, winter or summer...is assured—*all the way to the final control element* with Askania's Electro-Hydraulic Valve Actuator.

Check These Facts: Permits all Electric Control Throughout the System • Weatherproof Performance • Simple to Install—and Operate • Continuously responsive to small signal changes • Accurate Valve Positioning Assured by Force Balance Principle.

FEATURES: Valve Stem Speed...0.5 in/sec Valve Stem Thrust...600 lbs.
Valve Stem Stroke.....½ to 2 inches
Input Coil Resistance.....3,000-18,000 ohms
Input Signal.....approx. 75 milliwatts d.c.

Write **for Bulletin No. 200 for complete information on how "EHVA" control might be adapted to your control system.**

CONTROLS FOR INDUSTRY

ASKANIA REGULATOR COMPANY

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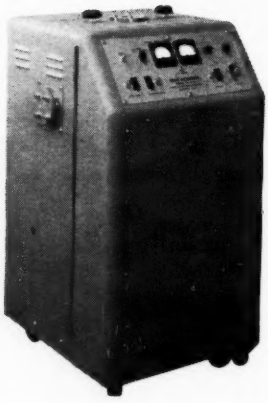
HYDRAULIC, ELECTRONIC CONTROLS & SERVOS, GENERAL SYSTEMS, ENGINEERING & COMPUTER SERVICE, VALVE ACTUATORS & CYLINDERS

A Subsidiary of General Precision Equipment Corporation

For more information circle **68** on inquiry card.

high-caliber weapon against leaks



This small, lightweight "sniffer", used in conjunction with Consolidated's world-famous *mass-spectrometer type* Leak Detector, is industry's most powerful means for combating leaks in hermetically sealed pressure or evacuated systems, large or small. Sensitive, rapid, economical and reliable, the mass-spectrometer method locates leaks *undetectable by any other method* ... and does it at mass-production rates! It's perfectly safe for both operator and the system under test and is the one *sure* way of protecting products against the ravages of moisture, dust, high altitude, corrosion, and arcing.

two models to fit your needs...

The standard Type 24-101A detects one part of helium (employed as an inert, perfectly safe tracer) in 200,000 parts of air ... measures leak rates to 10^{-9} std cc/sec. The ultra-sensitive Type 24-110 detects one part of helium in *2,000,000 parts of air!* It is valuable, for example, in atomic-reactor equipment and for the production of "reliable-type" electron tubes. SEND FOR BULLETIN CEC-1801D-X14.

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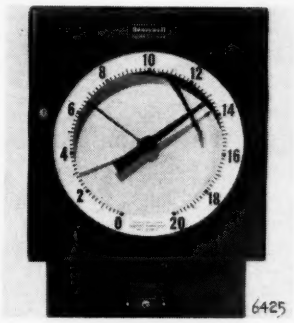
Sales and Service Offices in: Albuquerque, Atlanta, Boston, Buffalo, Chicago, Dallas, Detroit, New York, Pasadena, Philadelphia, San Francisco, Seattle, Washington, D. C.

For more information circle **69** on inquiry card.

PROCESS CONTROL

CONTROL SYSTEM FOR FURNACE REACTORS

New proportional-and-reset control system automatically regulates operation of saturable-core reactors used

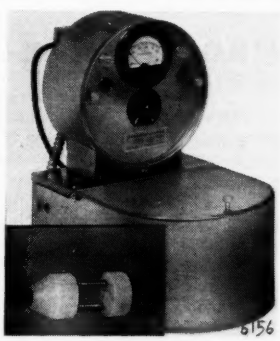


with resistance, high-frequency or induction furnaces. It comprises an electronic controller with an "Electr-O-Volt" controller; is designed for applications where it is undesirable to interrupt current for control purposes. New control unit is available as a special product.—*Minneapolis-Honeywell Regulator Co., Wayne & Windrim Avenues, Philadelphia* 44, *Pa.*

For more information circle **207** on inquiry card.

CONDUCTIVITY-PRINCIPLE SOLUTION CONTROL

New system said to improve efficiency of conductivity measurements in solution control features a newly-de-

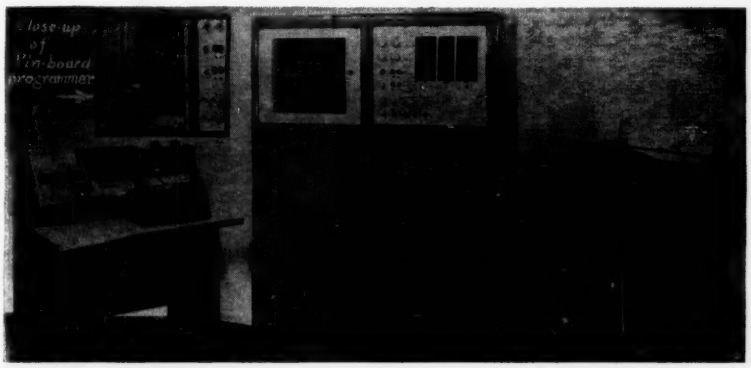


signed conductivity cell, transmitting signals to electronic control and feeder unit which constantly measures solution strength and feeds chemicals only when required, maintaining solution at predetermined strength. Heavy-duty electrode cell is made of stainless steel and polyethylene. Control circuit and feeder unit is of heavy-duty stainless steel construction. System is adaptable for chemical processing, acid or alkali solutions, metal cleaning and plating, water treatment, etc. —*The Diversey Corp.*, 1820 *Roscoe St., Chicago* 13, *Ill.*

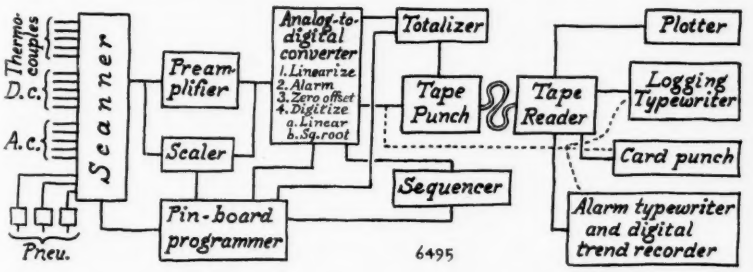
For more information circle **208** on inquiry card.

ELECTRONIC PROCESS-DATA-HANDLING SYSTEM

New "Data Handling System for the Chemical and Process Industries" accepts direct-voltage or alternating-voltage inputs from any combination of as many as 1000 thermocouples, resistance-type pickups, reluctance-type pickups,



etc. In a modern refinery (with hundreds of measuring points) it can do in seconds what would require "hours or days of human calculating." It is said to offer "versatility, ease of operation, accuracy and reliability not previously available in this type of equipment." Pinboard programmer allows easy digital control over the many systems functions (see diagram). Precision is 0.05%; over-all system accuracy is 0.1% of the value being read and not necessarily of full-scale. Large voltages are continually checked against a standard cell; "weighing" type analog-to-digital converter eliminates all ambiguity. Use of sealed

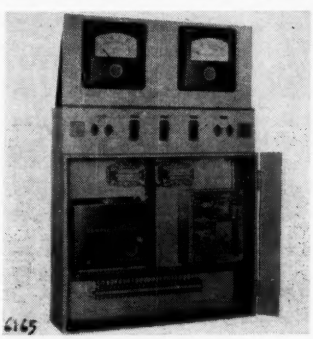


stepping switches and mercury-wetted contact relays assures reliability, even under severe environmental conditions. System construction is of standard plug-in modules mounted in sliding drawers accessible from front of cabinet, facilitating maintenance and allowing easy expansion.—*Beckman Div., Beckman Instruments, Inc., Fullerton, Calif.*

For more information circle **209** on inquiry card.

BURNER CONTROL SYSTEMS

New "Fireye AC Panel Control Systems" offer complete burner protection and fully automatic operation for oil, gas, and combination oil/gas burners; combine flame failure safeguard, programming control, short-circuit protection, motor starters, fuel selector switches, signals and alarms. Optional equipment includes sequence draft controls, draft and temperature indicators, and provision for switching to modulated, or fixed-rate firing. —*Electronics Corp. of America,* 718 *Beacon St., Boston, Mass.*



For more information circle **210** on inquiry card.

PRESSURE-TANK GAGE

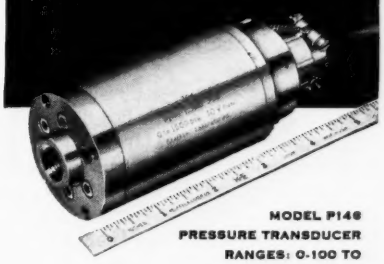
New "Levelux Fuelmaster" hydrostatic remote-reading tank gage can be used on tanks that operate under alternate pressure and vacuum. It uses two lines to the tank; one con-

Aerojet-General

LIQUID ROCKET PLANT AT SACRAMENTO

is dedicated to the advancement of rocket technology

THROUGH THE USE OF SUPERIOR INSTRUMENTATION TECHNIQUES



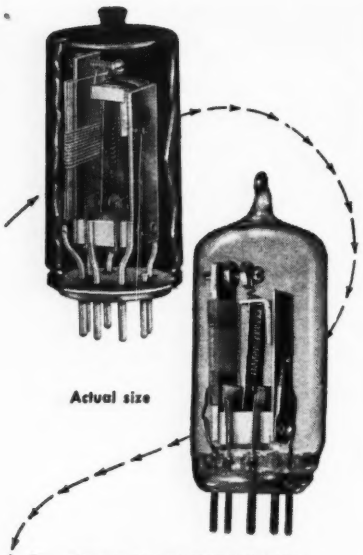
MODEL P146 PRESSURE TRANSDUCER RANGES: 0-100 TO 0-5,000 PSIG

Model P146 Pressure Transducers employing the Statham biradial unbonded strain gage were selected for use at this new facility because of their high accuracy, interchangeability and capacity to perform during the grueling tests required in the development of rocket engines.

Please request Bulletin No. P146.

Statham LABORATORIES LOS ANGELES 64, CALIFORNIA

For more information circle **70** on inquiry card.



CURTISS-WRIGHT

now offers

THE "SNAPPER" THERMAL TIME DELAY RELAY

Relied on for positive action and long life in scores of applications involving time delay in electrical circuits, the "SNAPPER," formerly produced by Elly Electronics Corp., is now a Curtiss-Wright product.

Single pole, double throw contact action eliminates chatter. These unique relays feature snap action, double throw, reliability, small size. They are adaptable to military and commercial applications. Time delay periods: preset from 3 seconds up. Envelope: metal, miniature (7 and 9 pin) or octal (8 pin). Glass, 9 pin only.

High-Low Differential Thermostat

The "SNAPPER" Thermostat is a single pole, double throw snap action temperature sensitive switch. Its snap action principle has been extended to provide a low differential thermostat with precision characteristics, at low cost.

Write for detailed data

ELECTRONICS DIVISION
CURTISS-WRIGHT
CORPORATION · CARLSTADT, N. J.

For more information circle **51** on inquiry card.

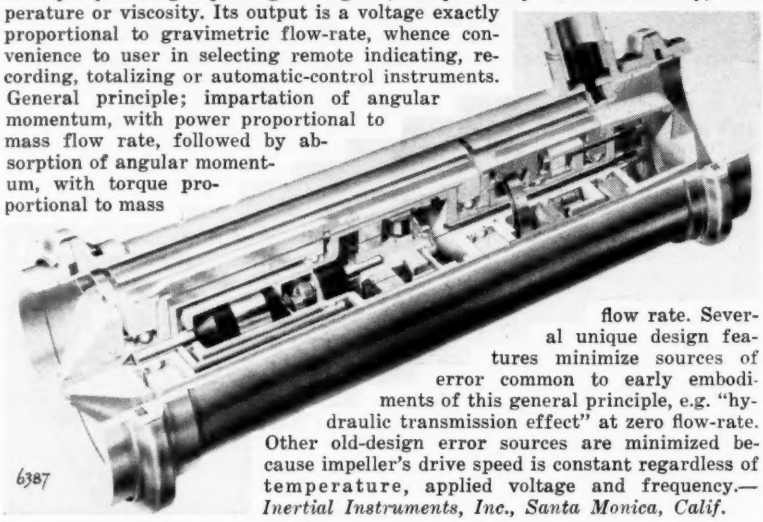
NEW INSTRUMENTS

nected with an airbell and the other to the vapor space for equalization. Head-responsive element is a bellows, whose motion is conveyed by magnetic coupling to actuate pointer. Dials (12" diam) can be furnished in any unit of liquid measure.—*Liquidvision Gauge & Control Corp., P. O. Box 51, Oceanside, Long Island, N. Y.*

For more information circle **211** on inquiry card.

MOMENTUM-PRINCIPLE MASS-FLOW-RATE METER

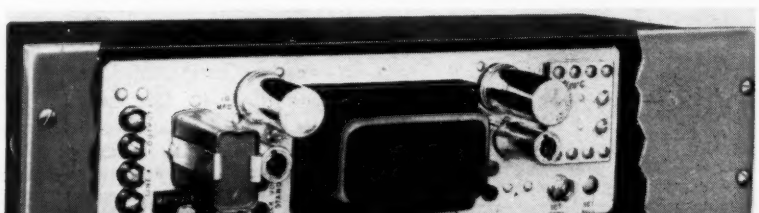
New "Inertial Mass Flowmeter" continuously measures mass-per-unit-time of any liquid or gas passing through it, independently of fluid's density, temperature or viscosity. Its output is a voltage exactly proportional to gravimetric flow-rate, whence convenience to user in selecting remote indicating, recording, totalizing or automatic-control instruments. General principle; impartation of angular momentum, with power proportional to mass flow rate, followed by absorption of angular momentum, with torque proportional to mass flow rate. Several unique design features minimize sources of error common to early embodiments of this general principle, e.g. "hydraulic transmission effect" at zero flow-rate. Other old-design error sources are minimized because impeller's drive speed is constant regardless of temperature, applied voltage and frequency.—*Inertial Instruments, Inc., Santa Monica, Calif.*



For more information circle **212** on inquiry card.

TRANSMITTING POTENTIOMETER

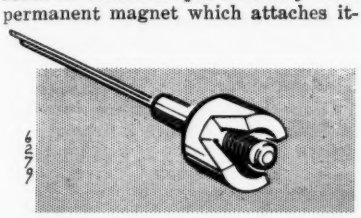
New "Type 184" transmitting potentiometer utilizes a new operating principle; permits measurement and control of low voltages while drawing negligible current from source; is available as a thermocouple pyrometer or to measure dc output of electrical primary elements. Its input emf is automatically balanced against output signal by "Microsen" balance which also maintains a constant reference voltage supply accurate to 0.5%, without periodic standardization. New unit is available in ranges from 6 to 50 mv (200° F. and up), with zero suppression up to five times span. Sensitivity better than 3 uv; output of 0.5 to 5.0 ma dc can be transmitted up to 30 miles; repeatability better than 10 uv; accuracy better than 1% under supply voltage changes from 90 to 130 volts; Speed of response for 10-mv range better than ¼ sec for 90% and increases directly with range.—*Manning, Maxwell & Moore, Inc., Stratford, Conn.*



For more information circle **213** on inquiry card.

SURFACE-TEMPERATURE TC

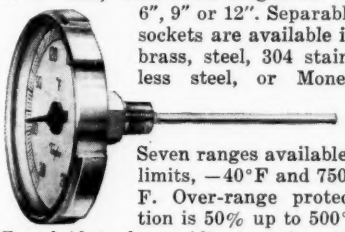
New "Magne-Kuple" is a novel form of thermocouple assembly with permanent magnet which attaches itself to surface and compresses a spring which, in turn, holds "button" (measuring junction) firmly against surface. Temperature limit 1000°F. Standard model is shown; others for non-magnetic materials, for holes, for curved surfaces, etc.—*Thermo Products Co., 177 E. Fairmount Ave., Milwaukee 17, Wis.*



For more information circle **214** on inquiry card.

DIAL THERMOMETER

New "Bi-Therm" is accurate to 1% of scale range; is available with 3" or 5" dial, with stem length of 4", 6", 9" or 12". Separable sockets are available in brass, steel, 304 stainless steel, or Monel.

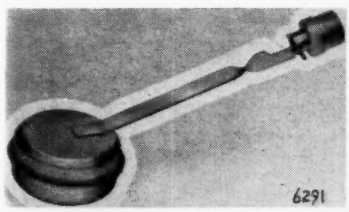


Seven ranges available; limits, —40°F and 750°F. Over-range protection is 50% up to 500°F and 10% above. All exposed metal parts are of arc-welded corrosion-resistant stainless steel.—*Taylor Instrument Companies, 95 Ames St., Rochester 1, N. Y.*

For more information circle **215** on inquiry card.

AUTOMATIC DISCHARGE FLOAT

New "Model C" controls level and flow of liquids in troughs, tanks, etc.; uses a continuous self-flushing principle to avoid clogging and flooding. —*Ward Machine Co., Brockton, Mass.*



For more information circle **216** on inquiry card.

CHART-DRIVE ASSEMBLY

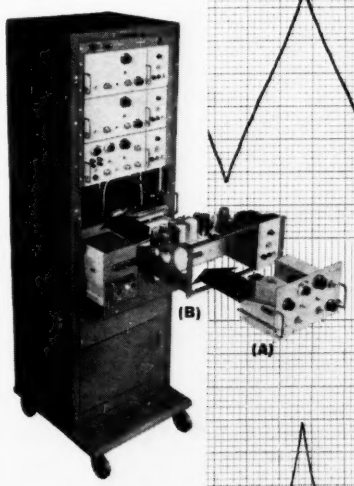
New air-operated chart drive assembly capable of postioning recorder charts at distances up to 250 ft is optional equipment for maker's "Tel-O-Set" recording instruments. Transmitter cam, operated by synchronous motor, moves a flapper to open and

SANBORN *Recording Permapaper*

ALL SANBORN 150 SERIES OSCILLOGRAPHIC RECORDERS PROVIDE THESE

SPECIFIC ADVANTAGES

The three foremost operating advantages of a Sanborn "150" are evident in the record, and are given at the right. Equally popular with industrial users is the *wide versatility* of these systems. Each one comprises a basic assembly to which the user adds his choice of an interchangeable, plug-in type preamplifier for each channel. Presently available different preamplifiers now number *eleven*.



Preamplifier (A) shown in position to plug into a Driver Amplifier with Power Supply (B) which are normally already in place in the Basic Cabinet Assembly

Rectangular Coordinate Recording

is a Sanborn feature that is especially valuable in multi-channel recording. The user of a 2-, 4-, 6- or 8-channel "150" system can record interrelated events simultaneously on one strip of record paper, and then correlate them against time quickly and accurately, even during the recording.

Clear, Sharp, Inkless Tracings

The nichrome ribbon tip "150" heated stylus removes the white opaque surface of Sanborn recording paper (Permapaper) permitting the black undercoating to show. Tracings are permanent, will not fade or smudge.

Improved Over-all Linearity

resulting from current feedback design of Driver Amplifiers and new shorted coil frame, high torque (200,000 dyne cm.) galvanometers. Maximum error over middle 4 cm. of chart: 0.25 mm . . . over entire 5 cm. chart width: 0.5 mm.

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195 Massachusetts Ave., Cambridge Mass.

A new "150" Catalog provides complete descriptive data, specifications and prices on all 150 Systems, Accessories and Cabinets. A copy will be sent on request.

For more information circle **71** on inquiry card.

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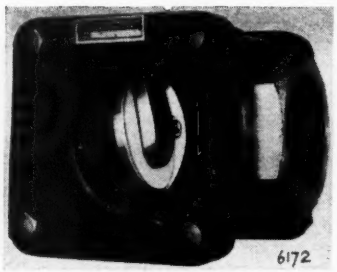
NEW INSTRUMENTS

close a nozzle. As flapper moves toward nozzle, air pressure at pilot valve builds up from 0 to 20 psi. This pressure, or "pulse," is converted to motion in receiver.—*Minneapolis-Honeywell Regulator Co., Philadelphia 44, Pa.*

For more information circle **217** on inquiry card.

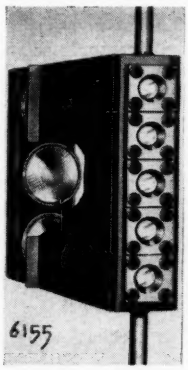
SIGHT FLOW INDICATOR

New "Fig. 213 Bull's Eye Check Valve Indicator" device has a self-aligning soft seat flapper which prevents back flow; two ½" thick windows on opposite sides of body fitting (removable for easy cleaning). Standard sizes are for 2" pipe (250 psi) and 1½" pipe (300 psi).—*Fischer & Porter Co., 544 Jacksonville Rd., Hatboro, Pa.*



For more information circle **218** on inquiry card.

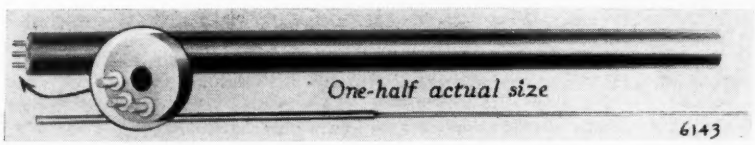
BICOLOR WATER LEVEL GAGE



New "Model MP-900 Multi-Port Gauge," featuring five larger ports for maximum visibility, is recommended for pressures up to 900 psi; vision length is 12". Either end stems or flanged connections. Applicable to existing or new boilers. Basic design is like that of high-pressure (3000

MOTION, POSITION AND VIBRATION PICKUP

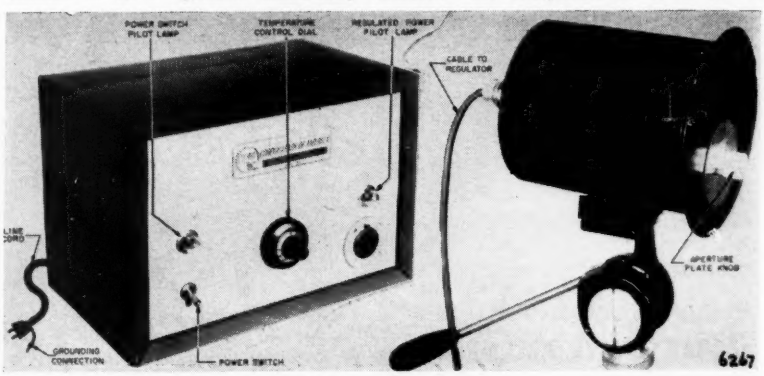
New "Miniature Linear Transducer" operates in temperatures from —160°F to 1300°F without cooling or other protection; is usable with most types of carrier equipment. Linear ranges from 0.2" to 4.0" are available; resolution 0.1 microinch; linearity 1.5% to 0.3% over linear range. No force is required to move sensing probe.—*Crescent Engineering & Research Co., 11632 McBean St., El Monte, Calif.*



For more information circle **219** on inquiry card.

ADJUSTABLE BLACKBODY RADIATION STANDARD

New "Servotherm Infrared Radiation Standard IRS-1," for calibrating and testing radiation pyrometers, thermistor bolometers, spectrometers, etc., is claimed to be a "perfect black-body radiator" for temperatures from 150°C to 600°C (302°F to 1112°F). Within this range, user can select any temperature by turning control dial: actual cavity temperature will be within 3 C° of dial scale reading. Error caused by line voltage variations of 105 to 125 is less than 1 C°. In addition to temperature setting, user can control radiant flux by selecting one of five apertures of different sizes.—*Servo Corporation of America, 20-20 Jericho Turnpike, New Hyde Park 1, L. I., N. Y.*



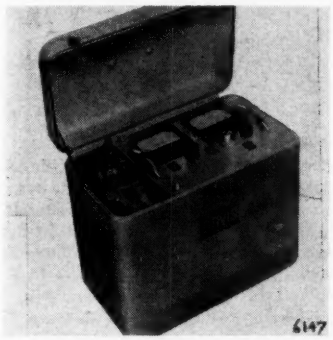
For more information circle **220** on inquiry card.

psi) "Multi-Port": a series of round ports with small individual glasses and mica and "Bi-Color." Green is water, red is steam; water level is always where colors meet.—*Diamond Power Specialty Corp., Lancaster, Ohio.*

For more information circle **221** on inquiry card.

COMBUSTION TESTER

New portable instrument for measurement of oxygen and combustibles in exhaust gases meets diverse test-

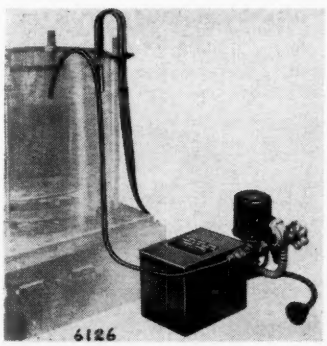


ing requirements of industries using different combustion processes. Oxygen ranges 0-5% and 0-21%; combustibles ranges 0-3% and 1-15%; both can be read simultaneously.—*Instrument Div., Davis Emergency Equipment Co., 55 Halleck Street, Newark, N. J.*

For more information circle **222** on inquiry card.

LIQUID LEVEL CONTROLLER

New "Portable Electronic Liquid Leveler" is applicable to all open type liquid containers; operates in



any electrically conductive liquid; maintains liquid level within 0.046"; includes relay, high and low level 18-8 SS probes, solenoid valve, 36" of nickel-plated copper tubing and brass needle valve. Power failure or tube burnout automatically cuts relay off.—*Blue M Electric Co., 138th & Chatham Sts., Blue Island, Ill.*

For more information circle **223** on inquiry card.

TC CONNECTOR SYSTEM

New "Do-it-yourself" thermocouple connector system permits almost any

DECADE RESISTANCES & VOLTAGE DIVIDERS

delivered from stock

Accuracy: 10 ohms and above: ±0.1%
1 ohm: ±0.25%
0.1 ohm: ±1%
0.01 ohm: ±5%

Temp. Coeff.: ±0.002% per degree C.
Maximum Load: ½-watt per step
Frequency Limit: Non-inductive to 20KC

DECADE RESISTANCE BOXES

Type	Dials	Ohm Steps	Total Resistance—Ohms	Price
817	3	0.01	11.1	$60.00
818	3	0.1	111	51.00
820	3	1	1,110	56.00
821	3	10	11,100	60.00
822	3	100	111,000	63.00
823	3	1,000	1,110,000	77.00
824	3	10,000	11,100,000	120.00
817-A	4	0.01	111.1	75.00
819	4	0.1	1,111	71.00
825	4	1	11,110	77.00
826	4	10	111,100	79.00
827	4	100	1,111,000	92.00
828	4	1,000	11,110,000	139.00
8285	5	0.1	11,111	94.00
829	5	1	111,110	101.00
830	5	10	1,111,100	113.00
831	5	100	11,111,000	155.00
817-C	6	0.01	11,111.1	105.00
8315	6	0.1	111,111	109.00
832	6	1	1,111,110	121.00
833	6	10	11,111,100	169.00

UNMOUNTED DECADE RESISTANCES

Type	Dials	Ohm Steps	Total Resistance—Ohms	Price
435	1	0.1	1	$12.00
436	1	1	10	13.25
437	1	10	100	13.25
438	1	100	1,000	15.00
439	1	1,000	10,000	16.00
440	1	10,000	100,000	18.50
441	1	100,000	1,000,000	32.50
442	1	1,000,000	10,000,000	60.00

DECADE VOLTAGE DIVIDERS (Potentiometers)

Type	Dials	Ohm Steps	Total Resistance—Ohms	Price
845	3	1	1,000	98.00
837	4	0.1	1,000	126.00
835	4	1	10,000	132.00
836	4	10	100,000	146.00

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Shallcross

For more information circle **72** on inquiry card.

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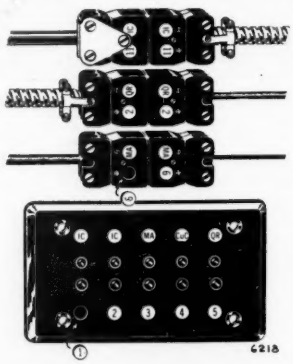
ENGELHARD INDUSTRIES

For more information circle **73** on inquiry card.

NEW INSTRUMENTS

type of TC connector used in laboratory or plant to be quickly and easily assembled from standard interchangeable parts. Components or complete

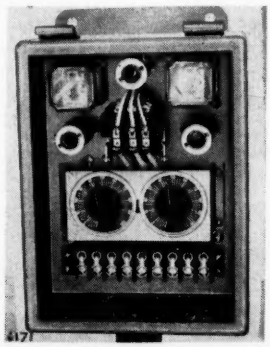


assemblies are available from stock. One-piece plug and jack inserts are made in four alloys for standard types of TCs.—*Marlin Mfg. Corp.*, 12410 *Triskett Road, Cleveland* 11, *Ohio.*

For more information circle **224** on inquiry card.

ELECTRONIC TIMER

New "Model T-3" features independently adjustable ON and OFF time ranges and dp-dt load contacts rated



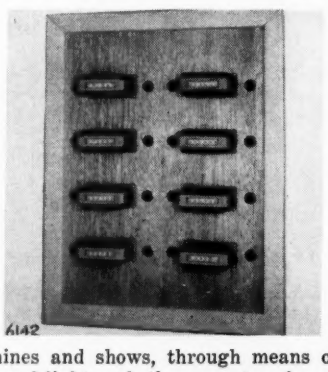
at 20 amp 115 vac, non-inductive load. Cold cathode tubes require no warm-up time. Accuracy is 1%. Standard ranges are 0.3-25 sec and 0.5-50 sec per section; others available.—*Ferrara, Inc.*, 8106 *W. Nine Mile Rd., Oak Park* 37, *Mich.*

For more information circle **225** on inquiry card.

COUNTING

MULTI-COUNTER PANEL

New remote-reading control panel registers production of only full-length parts on B&S automatic screw ma-



chines and shows, through means of signal lights, whether or not each machine is operating. It can be supplied in sizes to accommodate any number of counters and signal light sets. Locating new panelboard in record-keeping department simplifies keeping accurate cost-accounting records, ascertaining how long each machine runs without stock, determining how long each job should take, etc.—*Count-O-Larm Co.*, 1271 *W. North Ave., Chicago 22, Ill.*

For more information circle **226** on inquiry card.

PHOTOELECTRIC COUNTER

New inexpensive counting system "for even the smallest industries" is capable of 125 counts per second; is simplified enough for installation and servicing by plant electricians. Heavy-duty cast-aluminum enclosures house light source and photocell pick-up units. High-speed counter has heavy water-proof case with tamper-proof transparent cover.—*Berkeley Div., Beckman Instruments, Inc.*, 2200 *Wright Ave., Richmond* 3, *Calif.*

For more information circle **227** on inquiry card.

ADD-SUBTRACT COUNTER

New "Bulletin 1000 Differential Counter" provides count control for conveyors, transfers and machines.

Its gear train is driven by two continuous-duty solenoids (add and subtract). Two switches are adjustable by setting maximum (red) pointer; maximum switches then operate when counter reaches set count. Zero switch operates when dial pointer (black) is at zero count of shown outer dial. New counter will record electrical impulses received by add or subtract solenoid

in any combination: it will record simultaneous impulses; it will operate at rate of 200 per minute.—*Ralph D. Ernest Associates, Inc.*, 12818 *Puritan Ave., Detroit* 27, *Mich.*

For more information circle **228** on inquiry card.

DIGITAL READOUTS

New "NLS 3W Series," most advanced design of in-line luminous digital readouts originated by maker

in 1952, are available with one to six windows arranged horizontally. Numbers are ½" wide and 1" high. New feature: quick-change terminal strip which eliminates resoldering connections when replacing lamps.—*Non-Linear Systems, Inc., Del Mar Airport, Del Mar, Calif.*

For more information circle **229** on inquiry card.

AVIATION, etc.

VERTICAL GYROSCOPE SYSTEM

New "Model 40,000 Compensated Vertical Gyroscope System" provides for unlimited freedom in roll, and high angular freedom in pitch. Accuracy of ¼° from true vertical can be realized over a preset range of speed during straight flight and also during and after turns.—*Gyromechanisms, Inc., Halesite, N. Y.*

For more information circle **230** on inquiry card.

RATE GYROSCOPES

New fully-floated rate gyroscopes featuring high strength and great dimensional stability. Maximum size 2½" OD x 4½" length; maximum weight 2 lbs. Various motors available; flotation in silicone fluid; choice of damping systems; gyro angular momentum up to 10^6 gm cm^2/sec; a unusually high inertia ratio; high undamped natural frequencies.—*Gyromechanisms, Inc., Halesite, N. Y.*

For more information circle **231** on inquiry card.

RATE GYROSCOPE

New "Model 10" rate gyro is subminiature: envelope size 1¼" OD and 2¼" L. Output signal is high enough to obviate need of redundant amplification equipment commonly required for small-size rate gyros. Unit incorporates advances in fluid flotation of

REPEAT PERFORMANCE

The existence of the remarkable Sigma type 72 relay has been hinted at occasionally, starting back in '53 when it was suspected that we might finally have something here. In those days we played a little hard to get because (a) we weren't quite sure, and (b) *they* were hard to get. It even got to the point a year or so ago that we advertised it as the WORLD'S BEST RELAY* which was very carefully qualified: "*We can't prove this, but it is the opinion of the man who designed it." By now several 72's have completed half a billion operations and more in customer's telegraph printers, without even the necessity of prying open the ingenious repair kit** for contact or armature replacement. *Now* we're convinced and ready to give it a real bellow.

Basically, the 72 is a high speed polar relay whose REPEAT PERFORMANCE (get it? heh!) makes it admirably suited for telegraph service and useful for handling other forms of data up to 500 pps. Significant specifications are tabulated below, and to them we'd like to add the crucial one: Series 72 relays are available (an unusual Sigma feature).

SPECIFICATIONS Sigma Series 72 Relays

Operation; principal use	Polarized; telegraph service, data handling up to 500 pps.
Contact arrangement, life and load rating	SPDT; 5×10^8 @ 60 ma DC
Max. aperiodic pulse rate	500 pps
Max. following pulse rate	1200 pps
Vibration immunity	15 g to 500 cps even at highest sensitivity
Maintenance, adjustment	Bias, sensitivity adjustable; contacts, armature easily replaceable.

We won't horse around about the 72 any more. You don't have to beg us to sell them to you or for "fast" delivery. Just drop us a line and we'll see to it that you don't have a moment's peace until you buy some—we dare you.

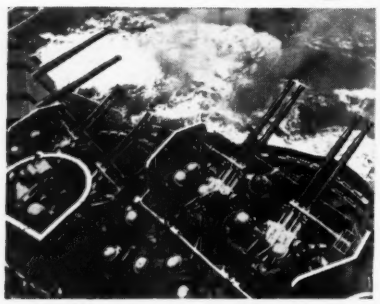
SIGMA

SIGMA INSTRUMENTS, INC.
75 Pearl St., So. Braintree, Boston 85, Mass.

For more information circle **74** on inquiry card.

MIL-L-7808B
MIL-L-6085A
MIL-G-3278

service and leadership



For dependable service and outstanding leadership both in meeting government specifications and in industry . . . the name of Anderol synthetic lubricants leads all others. Throughout World War II, the Lehigh Chemical Company developed and produced greases, oils, rust preventives and cleaning compounds for the Army and Navy, including almost one-third of a special machine gun oil required by the armed services. The company also manufactured synthetic petroleum sulfonates and special additives for the general lubricant industry. Lehigh has been producing synthetic lubricants in commercial quantities since 1944—considerably longer than any other manufacturer.

Anderol products include lubricating oil, grease, damping fluid, and slushing compound. In addition to these four typical products, a great many lubricants such as metal cleaners, degreasing solvents, emulsion cleaners, thixotropic oils, additives and special greases resistant to acids, solvents or water are also available.

WRITE TODAY:
For samples, complete data and government specification list. Our laboratories are at your service to produce any special lubricant you need.

Attention Manufacturers' Representatives:
Representation in various areas is open.

ANDEROL
SYNTHETIC LUBRICANTS
Lehigh Chemical Company
CHESTERTOWN, MARYLAND

For more information circle **75** on inquiry card.

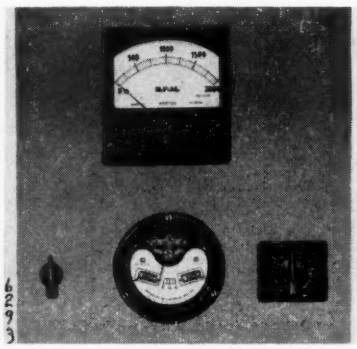
inertial elements. Gimbal structure is floated in a stable fluid having a density equal to that of gimbal system, whence "a previously unattainable immunity to extremes of acceleration, shock and vibration."—*Daystrom Pacific Corp.*, 3030 *Nebraska Ave., Santa Monica, Calif.*

For more information circle **232** on inquiry card.

SPEED MEASUREMENT and CONTROL

SPEED-CHANGE INDICATOR

New "Speed-change Sensing System," designed especially for use in precision automatic speed control

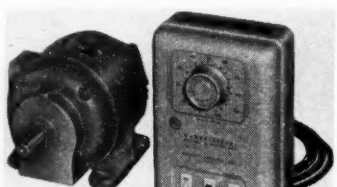


equipment, utilizes maker's frequency responsive system; will react to a speed change as small as 0.25% of its top operating speed; can be used at any speed up to 80,000 rpm. Circuit is extremely simple and, since no vacuum tubes are used, dependable maintenance-free operation is assured. Tachometer provides continuous speed indication.—*Weston Electrical Instrument Corp.*, 614 *Frelinghuysen Ave., Newark 5, N. J.*

For more information circle **233** on inquiry card.

VARIABLE SPEED DRIVE

New "Magne-Speed," available in two sizes, covering range from ¼ to 1½ hp, features stepless instant start-

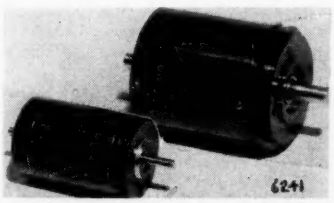


ing, no electronic components, 50:1 speed range with good regulation, and low cost.—*Magnetic Amplifiers, Inc.*, 632 *Tinton Ave., New York 55, N. Y.*

For more information circle **234** on inquiry card.

SPEED REDUCERS

New "Type #U" precision speed reducers are of universal design; variable ratios from 5:1 to 3000:1; oil-less bearing or miniature ball bearings ABEC-5 tolerances as required. Backlash measured through entire



train is less than 30 min. Two sizes available from stock: 1 1/16" dia, equal to MK-14 series; and 1¾" dia, equal to MK-8.—*PIC Design Corp.*, 160 *Atlantic Ave., Lynbrook, N. Y.*

For more information circle **235** on inquiry card.

SPEED CONTROL SYSTEMS

New complete 1- and 1½-hp "Variac" motor speed control systems are available at a reduction in cost of

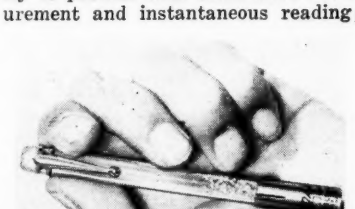
about 25% over earlier models. A small rugged inexpensive drum controller is used in place of magnetic contactors as switching unit for forward, reverse, and stop operations. Particularly suited for small lathes, among many applications.—*General Radio Co.*, 275 *Massachusetts Ave., Cambridge 39, Mass.*

For more information circle **236** on inquiry card.

NUCLEONICS

PEN-SIZE DOSIMETER

New "Radad" features (1) simplicity of use, self-contained and charged and re-charged by shaking without need of auxiliary equipment; (2) ability to provide both cumulative measurement and instantaneous reading;



(3) low price; (4) unlimited life if not heated above 212°F.—*Electromation Co., 116 So. Hollywood Way, Burbank, Calif.*

For more information circle **237** on inquiry card.

3-D SCINTILLATION PROBE

New scintillation probe is highly directional: focusing collimator has a 2" focal length: focal point so sharp

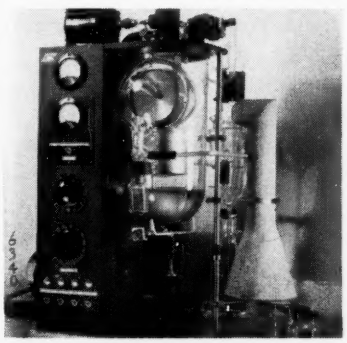
that it is possible to secure three-dimensional radiation patterns. This is said to be the first probe that permits securing such a pattern.—*Detectolab, Inc., 6544 Sheridan Rd., Chicago 26, Ill.*

For more information circle **238** on inquiry card.

LABORATORY EQUIPMENT

MOLECULAR STILL

New "CMS-5" laboratory-type centrifugal molecular still is said to offer "the only means of separating heat-



sensitive materials of high molecular weights up to 1200" and to insure "lower thermal hazard to the distillland than any other accepted distillation technique." It processes 0.1- to 1.5-liter samples at a rate of 0.03 to 10 grams of distillate per minute. —*Consolidated Vacuum Div., CEC, Pasadena 15, Calif.*

For more information circle **239** on inquiry card.

CASTOR PROCESS UNIT

New multi-purpose Castor Process Unit, by suitable selection of glassware, can be quickly set up for a variety of controlled organic reactions with a minimum of attention. Process parameters can be determined with sufficient accuracy for adoption in production units. Automatic timers will start unit before operator arrives and shut off process up to 20 hours after operator leaves. By simple

the NEW

USG SOLFRUNT®

(SOLID FRONT CONSTRUCTION)

the gauge with

BUILT-IN SAFETY!

There's safety with the new USG Solfrunt Gauge . . . behind the face is a solid metal wall! In the event of a Bourdon tube rupture, pressure is released through the large rubber blowout back. The case is of aluminum.

Like USG's Supergauge . . . with proper application . . . the Solfrunt is built to last a lifetime.

ARC-LOC MOVEMENT—Rugged beyond compare . . . broad generated gear faces, deep stainless steel bushings. Calibration adjustments from rear by merely removing blowout back.

SEGMENT—Stainless steel, with nylon-faced gear section. Nylon-to-metal bond stabilizes the nylon against expansion and contraction . . . maintains accurate pitch diameter . . . assures proper mesh with stainless steel pinion under severe temperature and moisture conditions.

LEGEND ON DIAL—gives complete description of socket, Bourdon tube, and movement material for ready identification.

MICROMETER ADJUSTABLE SELF-LOCKING POINTER—permits accurate repositioning of pointer.

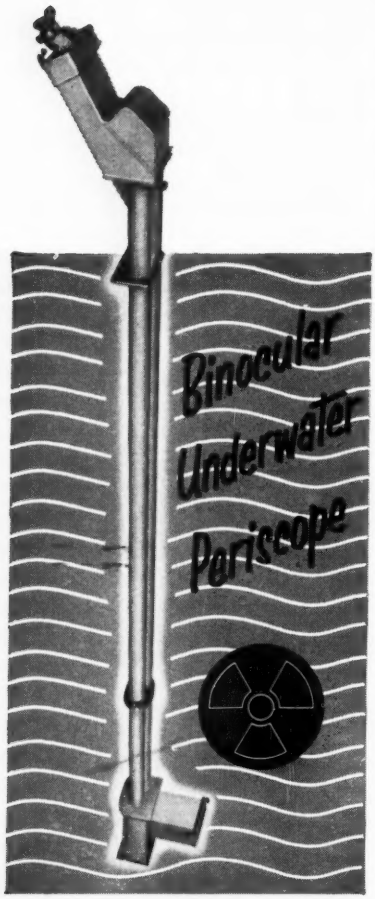
Solfrunt Gauges available in 4½", 6" and 8½" sizes. For complete information on case styles, materials of construction and connections, write for Publication 1819.

UNITED STATES GAUGE

Gauge Headquarters FOR OVER 50 YEARS

United States Gauge, Division of American Machine & Metals, Inc., 100 Clymer Avenue, Sellersville, Pa.

For more information circle **76** on inquiry card.



An industrial periscope is very often the answer to hard-to-get-at, underwater, hazardous location or Hot-Spot remote control observation. Ideal for use where heat, pressure or Hot Cell radiation are problems . . . the periscope offers unsurpassed clarity and definition, true color, and a long, maintenance-free service life. Attachments are available for photo recording all viewed material.

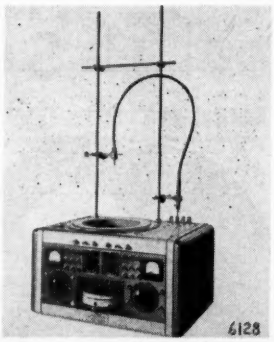
With our wide experience in this field, we probably have a design to fit your viewing problem. Send for Bulletin 301

KOLLMORGEN Optical CORPORATION

Plant: 347 King Street, Northampton, Mass.
New York Office: 30 Church St., New York 7

For more information circle **77** on inquiry card.

NEW INSTRUMENTS



switching, accessories can be operated through either manual or timer-controlled heater and pyrometer circuits. —*Burrell Corp.*, 2223 *Fifth Ave., Pittsburgh* 19, *Pa.*

For more information circle **240** on inquiry card.

CIRCULATED LOW-TEMP COOLANT SOURCE

Newly redesigned "Flow-Kold" low-temperature circulating refrigerant unit incorporates a cascade assembly of two Freon compressors which will produce a supply of coolant at −75° F (held constant within 1 F°); features quiet operation, light weight (395 lb) and low power requirement (940 watts). Pump's capacity 400 gph at zero head to 40 gph at 10-ft head.—*Podbielniak, Inc.*, 341 *E. Ohio St., Chicago* 11, *Ill.*

For more information circle **241** on inquiry card.

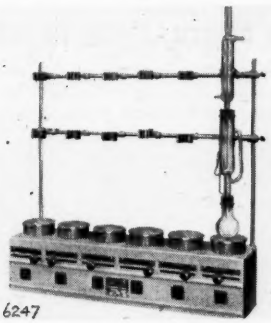
PHOTONEGATIVE NUMBERER

New "Serial Marker," for spectrographers, metallographers, etc., photographs a 4-digit number on a negative before developing. After number is photographed, a button is pressed which advances counter by one. Resetting is accomplished by turning a knob.—*Spex Industries, Inc.*, 80-56 *230th St., Queens Village* 27, *N.Y.*

For more information circle **242** on inquiry card.

EXTRACTION RACK

Newly redesigned "Vari-Heat," for extractive determinations employing either low- or high-boiling solvents,



features individual aluminum hot plates (in both 2-unit and 6-unit racks) for greater flexibility of operation; stepless heat control from 250° to 650°F. Individual line switches for each hot plate eliminate resetting rheostats between runs and assure repeatability.—*Precision Scientific Co.*, 3737 *W. Cortland St., Chicago* 47, *Ill.*

For more information circle **243** on inquiry card.

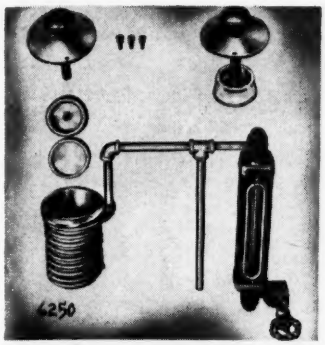
ROTATIONAL VISCOMETER

New "Precision-Interchemical Rotational Viscometer" is a high-speed wide-range instrument for determining viscosity, yield value and thixotropic breakdown of highly-viscous materials: paints, printing inks, plastics, greases, etc., with plastic viscosities in range of 1 to 2500 poises, and yield values up to 180,000 dynes/cm².—*Precision Scientific Co.*, 37337 *W. Cortland St., Chicago* 47, *Ill.*

For more information circle **244** on inquiry card.

EVAPORATION TEST CELL

New Evaporation Test Cell, originally designed for determining evaporation losses of low-viscosity lubricating oils used in sub-zero temperatures, can now be used for testing both greases and oils, regardless of their viscosity; is approved for test procedures of both the CRC and ASTM, is the only commercially available

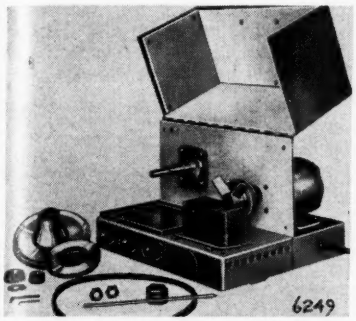


apparatus of its kind.—*Precision Scientific Co., 3737 W. Cortland St., Chicago 47, Ill.*

For more information circle **245** on inquiry card.

BEARING-LUBE TESTER

Newly redesigned "Wheel Bearing Grease Tester" meets ASTM Method D 1263 "Test for Leakage Tendencies



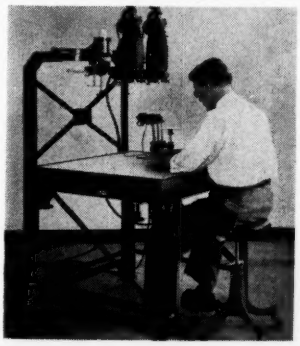
of Automotive Wheel Bearing Greases," also permits observation of changes in grease characteristics under service, consistency and structural changes, separation of oil or soap, formation of deposits on bearings, etc.—*Precision Scientific Co., 3737 W. Cortland St., Chicago 47, Ill.*

For more information circle **246** on inquiry card.

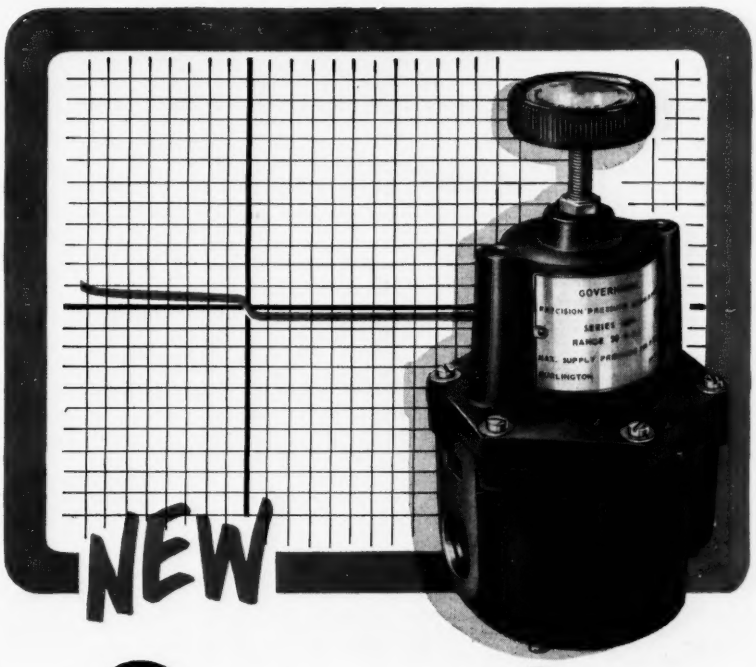
OPTICS

PHOTOGRAMMETRIC PLOTTER

New low-cost "Auxiliary Multiplex Plotter" is designed for use by educational institutions; is provided with a



ONLY ONE REGULATOR PROVIDES PNEUMATIC CONTROL LIKE THIS!



Governaire

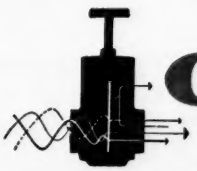
ZERO | ZONE

PRECISION PRESSURE REGULATORS

"Governaire" is the name of an entirely new design and achievement in precision controls for pneumatic loading. They differ from ordinary, existing instruments in their superior accuracy, greater reliability, improved immunity to variations in supply pressure and ability to fill or exhaust a remote volume far more rapidly. Typical flow curve shown above (Series 4000) graphically illustrates Governaire's minimum pressure offset effect as *Zero-Zone* is passed.

Typical specifications of the Series 4000 Regulator include five ranges (10, 30, 60, 150 and 250 psi); high capacity ⅝" diameter supply and exhaust seats (no other regulator of equal pipe size has even a *supply* capacity equal to the Series 4000 *exhaust* capacity); three sizes (⅜", ½" and ¾" NPT with two ¼" gauge taps). The Series is especially suited to such machine applications as welding head pressure control, punch press brake and clutch control, cable and sheet tensioning devices, etc.

Series 4000 is one of eight Governaire precision control devices now in production and available for delivery. Descriptive information and performance data on any will be sent on request. Write, outlining your application.



Governaire

DIVISION OF BELLOFRAM CORPORATION
BURLINGTON, MASSACHUSETTS

For more information circle **78** on inquiry card.

tracing table, two projectors, a supporting unit with current control, and two sets of 3-D viewing glasses.—*Bausch & Lomb Optical Co., 635 St. Paul St., Rochester, N.Y.*

For more information circle **247** on inquiry card.

ITV ZOOM LENS

New "Auto-Zoom Model 16TV" motor-driven zoom lens with a 5-1 (30—150mm) focal length range is the first one applicable to 16mm TV

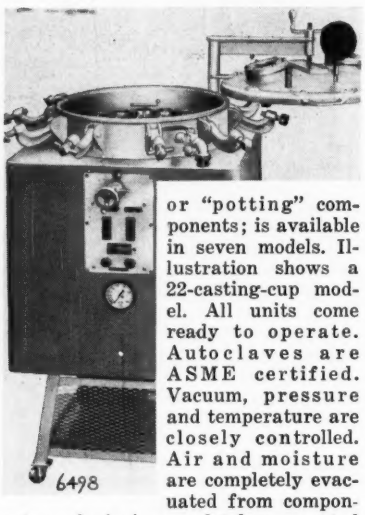
use; has been designed expressly for use with "Vidicon" tube; is said to be of optical quality "superior to any existing variable-focal lens."—*The Perkin-Elmer Corp., Norwalk, Conn.*

For more information circle **248** on inquiry card.

SHOP EQUIPMENT

AUTOMATIZED "POTTING"

New Encapsulating Machine assures absolute control of all important variables in casting or embedding

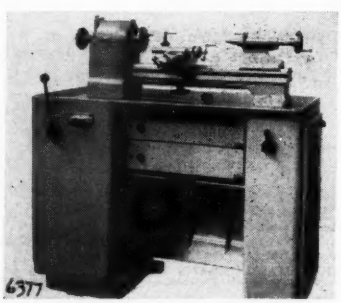


or "potting" components; is available in seven models. Illustration shows a 22-casting-cup model. All units come ready to operate. Autoclaves are ASME certified. Vacuum, pressure and temperature are closely controlled. Air and moisture are completely evacuated from components and air is completely evacuated from encapsulating compound before casting.—*Red Point Products, Inc., Glendale 1, Calif.*

For more information circle **249** on inquiry card.

LATHE CABINET STAND

New "SV 102-80" cabinet stand increases range and usefulness of "Schaublin" lathe. Pedestal is a one-piece casting, each one made to accommodate a series of standard units.

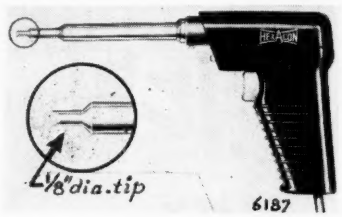


Many accessories available.—Sold and serviced in the U. S. by *Carl Hirschmann Co., Inc., Manhasset, N. Y.*

For more information circle **250** on inquiry card.

SMALL-TIP SOLDER GUN

New "Instant Solder Gun" has ⅛" tip for finest soldering; weighs 8 oz. Trigger control gives any degree of



heat required without danger of overheating.—*Hexacon Electric Co., 179 W. Clay Ave., Roselle Park, N. J.*

For more information circle **251** on inquiry card.

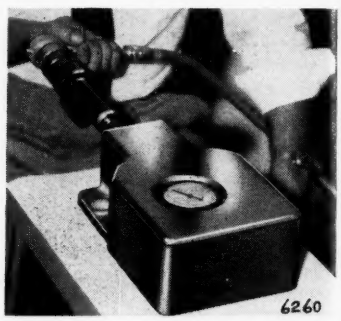
MINIATURE SCREWS

New line of "minicaps" and "minisets," miniature hex-socket cap and set feature: diameters of No. 0 through No. 3, lengths from ⅛" to ½"; coarse and fine series.—*Allen Mfg. Co., Hartford 2, Conn.*

For more information circle **252** on inquiry card.

TORQUEMETER FOR POWER SCREWDRIVERS

New "Torque Analyzer" rapidly indicates torque and points to trouble in defective tools without disassembly.



Principle: driving a stud in a nut against a pressure gage. Stud-and-nut is ball-bearing to assure high accuracy.—*Richmont, Inc., 922 S. Myrtle Ave., Monrovia, Calif.*

For more information circle **253** on inquiry card.

INSPECTION and GAGING

CAVITY-INSPECTION 'SCOPE

New "Endoscope" (imported) eliminates costly dismantling and saves time in all types of "blind" inspection; features self-contained lighting and lenses that transmit accurate image to eyepiece or to a camera. Available with hinged and fixed devices for bottom, rearward, forward and angular viewing. Diameters as small as $\frac{3}{16}$" and lengths up to 23 ft.—*Homestrand, Inc., 9 Addison St., Larchmont, N. Y.*

For more information circle **254** on inquiry card.

ABRASIVE-GRINDING-WHEEL PARALLELISM GAGE

New "Model 256-B-70" measures parallelism on several sizes of grinding wheels. Three "Electricator" gaging units are used, in connection with a triangular plate. If all three contacts are neither higher nor lower than reference (within a specified tolerance), green light flashes; otherwise

WHY POWERS No. 11 REGULATORS Give BETTER CONTROL and Last Longer

TEMPERATURE Indicating Regulator with Single Seat Valve

Better **TEMPERATURE** Control results from powerful bellows and minimum of valve stem friction. Valve Stem Lubricator aids easy movement of valve stem without binding. Double ply metal used in Powers bellows outlasts ordinary single ply type.

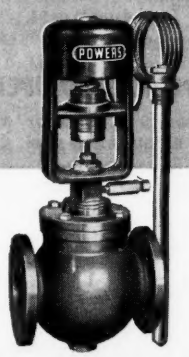
Simplest, Reliable **TEMPERATURE CONTROL** made for: Many Industrial Processes, Heat Exchangers, Air Compressors, Diesel Engines, Fuel and Crude Oil Heaters and Treaters.

SELF OPERATING Needs no Electricity.

Balanced (Double Seat) Valve

Controls Flow of Steam, Water or Gas

EASY TO INSTALL bronze union connections for single and double seat valves thru 2" save installation time and labor.



(c44)

Above: Flanged Iron Body Valve with Double Seat for sizes above 2"

● **15 to 20 Years of reliable service** is often reported by users of Powers Temperature Regulators. Since 1891 they have been noted for their sturdy construction and dependability.

● Right type of Regulator and the right size valve is important for best control. From Powers complete line of self operating regulators and air operated temperature controllers you can be sure of getting the type best suited for your requirements. Call our nearest office or write us direct. 3400 Oakton St., Skokie, Illinois. Offices in Chief Cities.

POWERS CONTROL

Since 1891

THE POWERS REGULATOR COMPANY

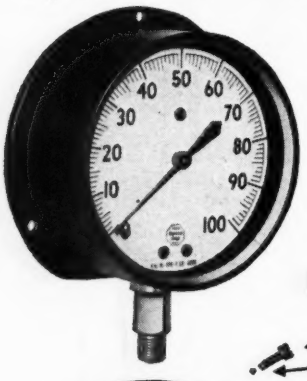
For more information circle **79** on inquiry card.

an ACCO product

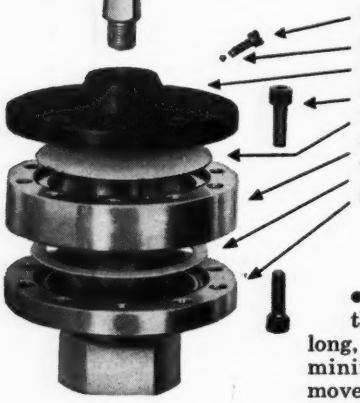
Helicoid Chemical Gage

Gages for corrosive chemicals and liquids up to 5000 p.s.i.

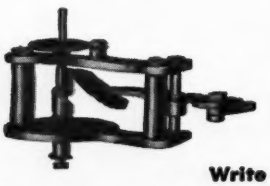
● Here's an accurate pressure gage for chemicals and other viscous liquids which might corrode or clog the Bourdon Tube. It registers working pressures from 30" vacuum to 5000 p.s.i. and temperatures to 400° F. Guaranteed accuracy plus or minus 1%. A single diaphragm seals off objectionable substances from the indicating gage. This gage is filled completely with specific inert liquids and pressure is transmitted directly to the indicating gage through deflection of the sealing diaphragm.



FEATURES



● HELICOID GAGES cost less in the long run because they give long, trouble-free service with a minimum of maintenance. The movement is a simple cam and roller design that does not have any gear teeth to wear out. It has been tested and proved in years of hard service.



Only Helicoid Pressure Gages Have the Helicoid Movement

Write for Catalog Today

ACCO

Helicoid Gage Division

AMERICAN CHAIN & CABLE

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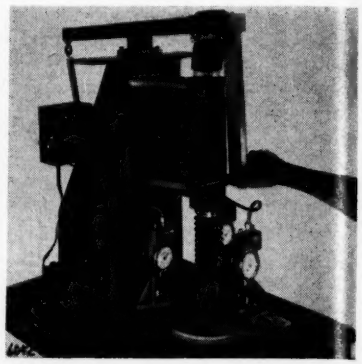
For more information circle **80** on inquiry card.

NEW INSTRUMENTS

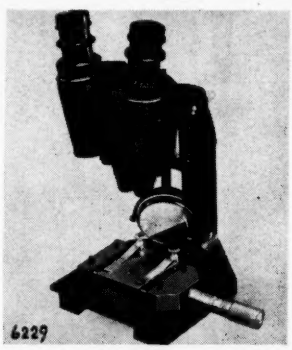


the appropriate off-tolerance light will be lit. Dials indicate amount of error and location of off-tolerance area.—*Federal Products Corp.*, 1144 *Eddy St., Providence* 1, *R. I.*

For more information circle **255** on inquiry card.

STEROSCOPIC MICROSCOPE

New "Model O-245S" wide-field microscope for tool and instrument makers is primarily for stereoscopic

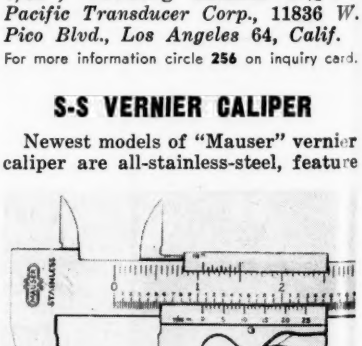


viewing and fine measurement of opaque objects. It has a single axis micrometer stage and crossed-hair reticle for measurement in mils. Two sets of eyepieces give magnifications of 12½× and 37½×. Field of view 9/32"; working distance 2-¾".—*Pacific Transducer Corp.*, 11836 *W. Pico Blvd., Los Angeles* 64, *Calif.*

For more information circle **256** on inquiry card.

S-S VERNIER CALIPER

Newest models of "Mauser" vernier caliper are all-stainless-steel, feature

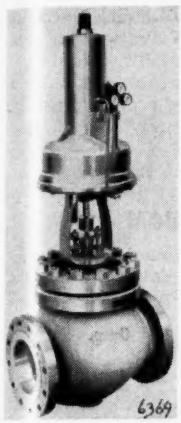


dull-chrome finished vernier slides to eliminate glare and reflection.—*George Scherr Co, Inc.*, 200 *Lafayette St., New York* 12, *N. Y.*

For more information circle **257** on inquiry card.

VALVES

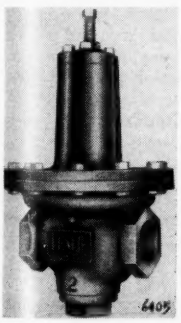
CONTROL VALVES



New "S-3000 Series" valves are said to "represent the first basic departure in control valve design and overcome all present-day limitations." New body design provides extra-large bowl capacity to insure a high coefficient of flow without involving excess body weight. All internal parts are removable through bonnet. Action can be reversed by inverting superstructure. Plugs in valves 2" and larger are of balanced design and can be supplied with a special device for tight shut-off. Integral positioner is said to have "proven superior in speed and sensitivity to all standard positioners now in us." Sizes: ½" to 8".—*Hammell-Dahl Co.*, 175 *Post Road, Providence* 5, *R. I.*

For more information circle **258** on inquiry card.

REDUCING VALVES



New "Hi-Flo Regulators" are classes W-1 and WL-1 valves for water and other non-corrosive liquids; are said to have "50% to 100% greater capacity than other regulators." Among features: Large bowl construction and long travel diaphragm for full flow; fully-balanced; high-strength balancing diaphragm; renewable trim with interchangeable fit. Sizes: ½" to 2". Inlet range 10-250 psi, 180°F; reduced pressure ranges 5-30 psi or 25-80 psi. Minimum pressure drop 5 psi—*Leslie Co.*, 120 *Delafield Ave, Lyndhurst, N. J.*

For more information circle **259** on inquiry card.

MOTORIZED VALVES

New control valves feature oil-immersed reversing motor; include a transformer with 110-v or 220-v primary. Motor's 3-wire control circuit can be operated by any thermostat,

New speed–
New savings–
on PRODUCTION-LINE TESTING

Here's new help in stepping up production and reducing the learning curve for inexperienced personnel . . . Hycon's Model 615 *Digital* VTVM. It *can't* be read incorrectly; the fast, reliable* 3-digit counter shows measurements in numerical form, positively eliminates interpolation errors. Standard accuracy 1%; can be supplied with 0.1% accuracy and automatic print-out system. The 615 is ideal for production-line testing, for incoming parts inspection and for high-precision laboratory work.

Another Hycon test help . . .

MODEL 625 DIGITAL RATIOMETER
Shows ratio of two related voltages on large, easily read counter. Reads out in average 1 to 2 seconds.

*Hycon counters are specially engineered for long service . . . prototypes have been continuously cycled in excess of 1,000 hours . . . the equivalent of at least 20 years of average use. Counters backed by unqualified, 500-hour continuous-use service guarantee.

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For more information circle **81** on inquiry card.

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SYNCHROS
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extreme accuracy
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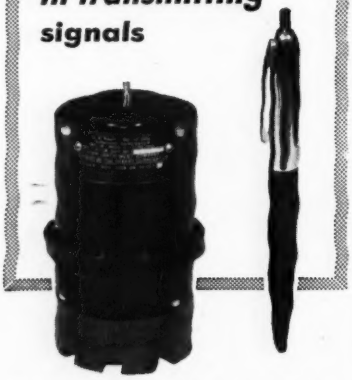

STANDARD TELESYN SYNCHROS
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Size 1 Size 3 Size 5

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A pioneer in the field of synchronous transmission, Ford Instrument produces synchros of proven precision accuracy.

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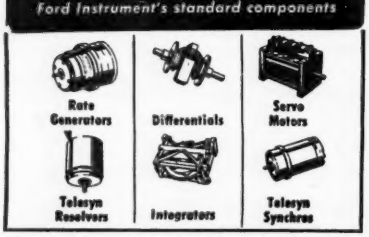
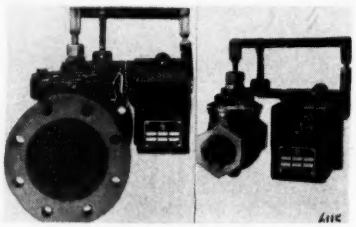
43A

Ford Instrument's standard components



For more information circle **82** on inquiry card.

NEW INSTRUMENTS

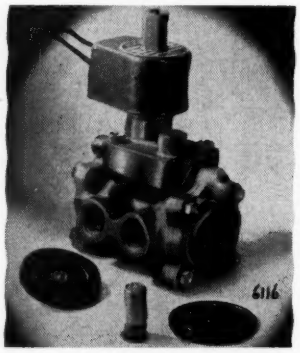


pressure switch, etc., having sp-dt contacts. Speed options: 30-second, 1-, 2-, 4- or 6-minute for 90° arm travel.—*An-Temp-Co. Corp., 657 Broadway, New York 12, N. Y.*

For more information circle **260** on inquiry card.

3-WAY SOLENOID VALVE

New "Bulletin 8316" packless 3-way solenoid valve utilizes new operating principle; is internal-pilot-operated;



has three operating parts—two Hycar diaphragms and one stainless steel solenoid core; can operate under severest conditions at up to 400 cycles per minute. Available in ⅜" or ½" sizes; rated for 250 psi on liquids and gases.—*Automatic Switch Co., 391 Lakeside Ave., Orange, N. J.*

For more information circle **261** on inquiry card.

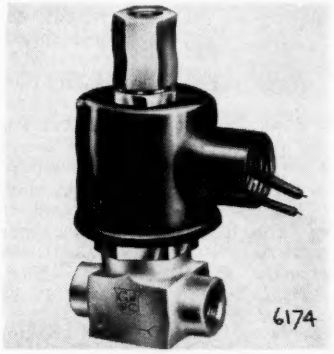
GAS VALVE

New "V-80" gas valve with moving parts cushioned in oil to assure silent operation is said to combine "the best features of both diaphragm and solenoid type valves." Its sealed oil-filled power-head contains magnetic operator; controlled-viscosity oil damps plunger stroke, making valve especially suitable for home-heating equipment installed near living rooms or sleeping quarters. Valve seat inclined at 45° reduces possibility of foreign materials lodging on seat, also reduces dealers' and utilities service problem. —*Minneapolis-Honeywell Regulator Co., Philadelphia 44, Pa.*

For more information circle **262** on inquiry card.

3-WAY SOLENOID VALVE

New 3-way directional flow or mixer valve is said to have "3 times the life expectancy of previous models."



Normally opened or closed; choice of flow patterns; synthetic seats for tight shutoff; operates in any position; moisture-resistant low-current continuous-duty coils available for standard line voltages and frequencies; optional explosion-proof covers. —*General Controls, Glendale, Calif.*

For more information circle **263** on inquiry card.

MECHANICAL TESTING

CENTRIFUGE

New "Vari-G" centrifuge simulates the flight of a rocket; enable user to test two one-pound specimens simultaneously up to 300 *G* and two ten-pound units up to 100 *G*; is designed primarily for production testing; reaches peak velocity in less than 0.15 sec.—*Hycon Mfg. Co., 2961 E. Colorado St., Pasadena 8, Calif.*

For more information circle **264** on inquiry card.

BRINELL HARDNESS TESTER

New air-operated semi-automatic "Air-O-Brinell" is of light-weight cast-aluminum construction; provides operating simplicity and convenience. Once pressure is set for desired load, hardness tests are made in rapid sequence: operator inserts specimen and flips test switch; Brinell ball is automatically lowered and preset load

ENGINEERS

NEW 2-FOLD RETIREMENT INCOME PLAN

for Aviation and Missile Engineers

It's natural that a long-time leader in aviation, like Republic—with many firsts to its credit—should be a leader, too, in providing for the welfare of its staff. Right in line with this forward-looking policy is the remarkable new Republic Retirement Income Plan. Here is how it works:

PART 1 *is a basic Retirement Income plan paid for* entirely *by Republic Aviation.*

PART 2 *is a cooperative effort. It is completely optional. But if an engineer wishes to increase his retirement fund, by making a small monthly payment, Republic will* MORE THAN MATCH *his contribution.*

Take the case of a hypothetical engineer who joins Republic on January 1st, 1956, averages $8,000 a year for 15 years; then retires aged 65. If he elected PART 2 of the plan, he will have a total *monthly retirement income of $225.80,* including his social security. For this he himself will contribute *only $8.50 a month* to the Republic Retirement Income Plan.

Of course, the *MORE YOU EARN, the HIGHER your Retirement Income* will be. And Republic pays a top salary scale in the industry.

...RETIREMENT PLAN JUST ONE OF MANY PLUS FACTORS POINTING TO A REPUBLIC CAREER

FIRST — there's the interest and prestige of working for a pioneer in aircraft design, creator of such famous planes as the F-84 Thunderjet, the F-84F Thunderstreak, RF-84F Thunderflash and XF-84H. (Soon to be followed on the production line by the new F-103, F-105 and RF-105.)

SECOND —the company is expanding sharply, providing frequent opportunities for able men to advance. In fact a $12,000,000 increase in the Research and Development Program has just been announced.

THIRD —an All-Expense Paid Relocation Plan for qualified engineers living outside the New York City and Long Island areas, which makes it easy to move to Republic. Other liberal benefits: Life, Accident and Health Insurance; Hospital-Surgical Benefits for the whole family; educational aid covering ⅔ the cost of collegiate and graduate study.

Serve your own best interests. Make full inquiries into the many advantages of joining Republic now, not the least of which is living on Long Island—the Playground of the East.

Important engineering positions are now open at all levels:

STAFF ENGINEERING
PRELIMINARY DESIGN
ELECTRONICS
WEAPONS SYSTEMS PROPOSALS
OPERATIONS RESEARCH
SYSTEMS
MATHEMATICAL ANALYSES
AERODYNAMICS
TECHNICAL WRITING
DYNAMICS
ELECTRO-MECHANICAL DESIGN
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AIRCRAFT
Assistant Chief Engineer, Administration, **Mr. R. L. Bortner**
Farmingdale, Long Island, N. Y.

MISSILES
Administrative Engineer, Mr. Robert R. Reissig
Hicksville, Long Island, N. Y.

applied to test specimen.—*Tinius Olsen Testing Machine Co., Willow Grove, Pa.*

For more inforamtion circle **265** on inquiry card.

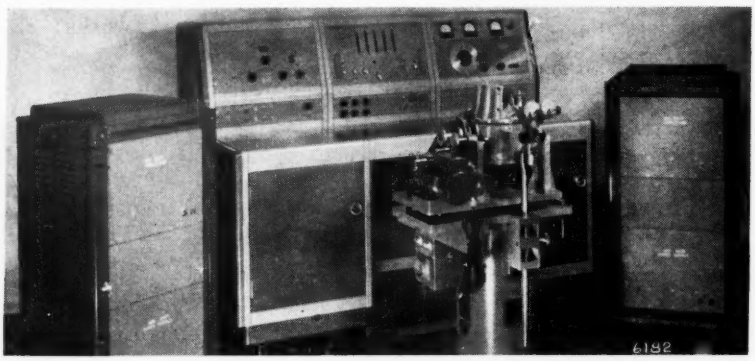
TC-TUBE LEAK TESTER

New "Protection Tube Leak-Checker" provides a new method of detecting molten or gaseous leaks in thermocouple protection tubes immersed in liquid materials. Instrument utilizes conductivity of molten or gaseous salt or metal to indicate leaks: molten material leaking into the protection tube closes alarm circuit. Pressing button applies test voltage to this circuit: if a leak has closed circuit, a warning light flashes. Test voltage does not damage pyrometeric instrument.—*The Peerless Electric Co., Warren, Ohio.*

For more information circle **266** on inquiry card.

GYRO SERVO TEST TABLE

New "Dynamic Integrating Gyro Servo Test Table" can measure sixteen characteristics of gyro, among them: drift rate; characteristic time; angular

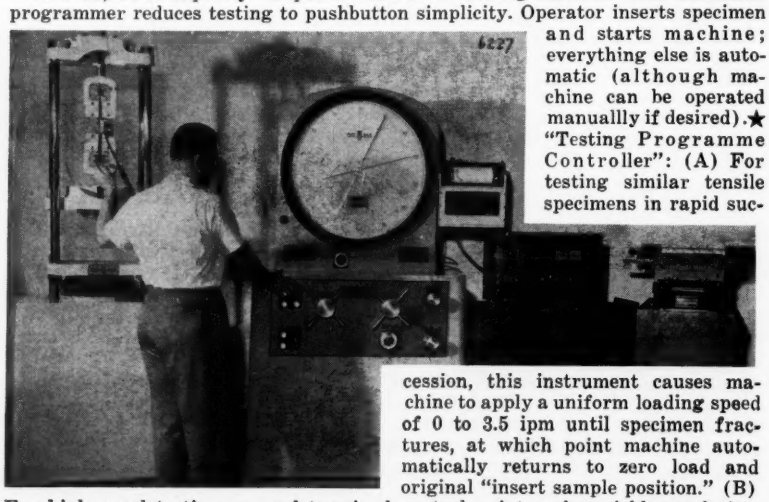


velocity input voltage rate output sensitivity; minimum rate detectable; high and low limit angular velocity deviation of performance; signal-generator and torque-generator linearity; spin motor excitation frequency, voltage and current.—*Greenleaf Mfg. Co.*, 7814 *Maplewood Industrial Court, St. Louis* 17, *Mo.*

For more information circle **267** on inquiry card.

AUTOMATIZED TESTING MACHINE AND DATA PRINTER

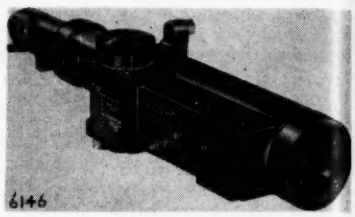
New 60,000-lb capacity "Super L" universal testing machine with automatic programmer reduces testing to pushbutton simplicity. Operator inserts specimen and starts machine; everything else is automatic (although machine can be operated manuallly if desired).★ "Testing Programme Controller": (A) For testing similar tensile specimens in rapid succession, this instrument causes machine to apply a uniform loading speed of 0 to 3.5 ipm until specimen fractures, at which point machine automatically returns to zero load and original "insert sample position." (B) For high-speed testing, a predetermined control point and a yield speed time are set on separate dials; a fast approach speed, plus a slow "yield" speed and a "very fast" tensile speed are also selected. ★ New "Automatic Data Printer" is essentially a data converter and electric typewriter. Operator selects desired percentage of offset and operates testing machine either manually or automatically. When electronic "stress-strain curve" intersects with desired offset, typewriter prints actual load in pounds applied to specimen at that instant. ★ Automatic self-balancing recorder can be used to plot conventional stress-strain curve simultaneously.—*Tinius Olsen Testing Machine Co., Willow Grove, Pa.*



For more information circle **268** on inquiry card.

AUTO-COLLIMATOR

New "Model D-600 Comparison Auto-collimator" utilizing a novel principle can be shifted and moved at will;



needs no fixed base or position to secure repeat readings of same or different surfaces; is designed for quick and continuous operation; can be used as a separate testing instrument or built into a test fixture. Several auto-collimators can thus be employed together.—*Davidson Mfg. Co., West Covina, Calif.*

For more information circle **269** on inquiry card.

VIBRATION EXCITER

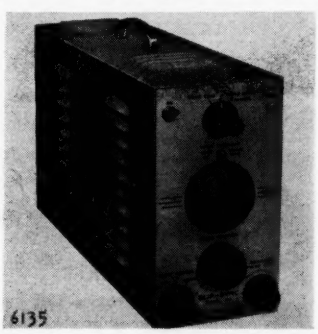
New "Model C10" air-cooled electrodynamic vibration exciter provides 1200 lbs force, frequency range from

5 to 2000 cps, and 1" total displacement; is available with either rotary-type or electronic power supply and control cabinets. Optional accessories include automatic cycling, frequency cycler, and degaussing coil.—*MB Mfg. Co.*, 1060 *State St., New Haven, Conn.*

For more information circle **270** on inquiry card.

STROBOSCOPE SYNCHRONIZER FOR VIBRATION TESTING

New "Model 103 Clip-Sync" provides completely automatic synchronization of strobe lights for observing

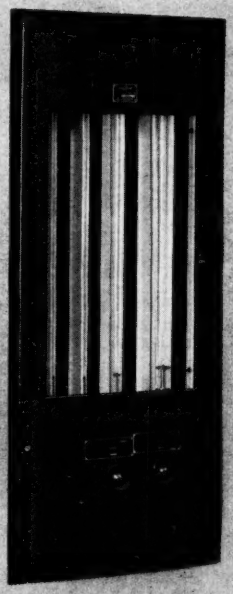


Holds No Terror

TYPE II VISCOMETER

A new laboratory-field instrument, using advanced flow system design, which quickly indicates kinematic viscosity of fuels, oils, weak acids and other base solutions. Two ranges available: .5 to 5.0 and 3.0 to 30 centistokes. Readability: within 1%. Portable or panel mounted.

COX INSTRUMENTS
prove this day-in-and-out
IN THE LABORATORY . . ON PRODUCTION LINES



Forty-three years ago, Commercial Research Laboratories produced the *first* precision Cox instruments — far advanced for their day. The name Cox has since become synonymous with accuracy and reliability wherever testing devices are used. So much so, in fact, that scores of aircraft, automotive, and hydraulic equipment manufacturers — here and abroad — have made a common practice of *calling in CRL first* — for expert advice in the design, development and manufacture of *any* hydraulic or air flow measuring device, large or small.

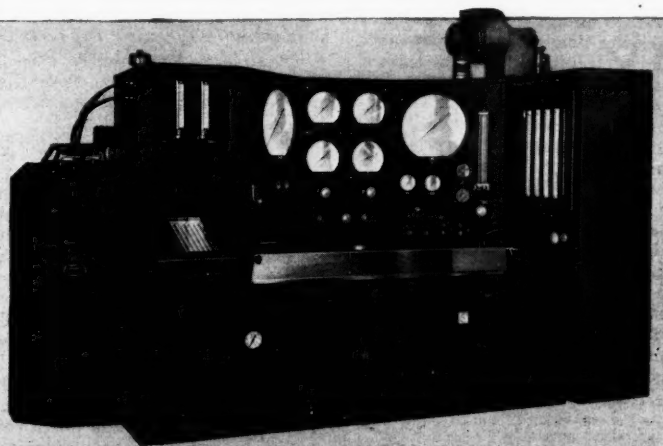
If your own requirements call for the smallest production-model flowmeter, or the most intricate, complete test stand — call in CRL first. Save time—and get dependability *plus* accuracy.

TYPE 12 FLOWMETER

Available in three series — 40, 90, 100 — Cox Type 12 Flowmeters combine high precision performance, outstanding readability, and unusually low cost. All Cox Flowmeters — including the Single Stage Type 8, the automotive Type 10, and the Type 14 for pressures up to 1000 p.s.i. — feature patented "Inner Wall" guides which permit individual matching of tube and float for optimum results.

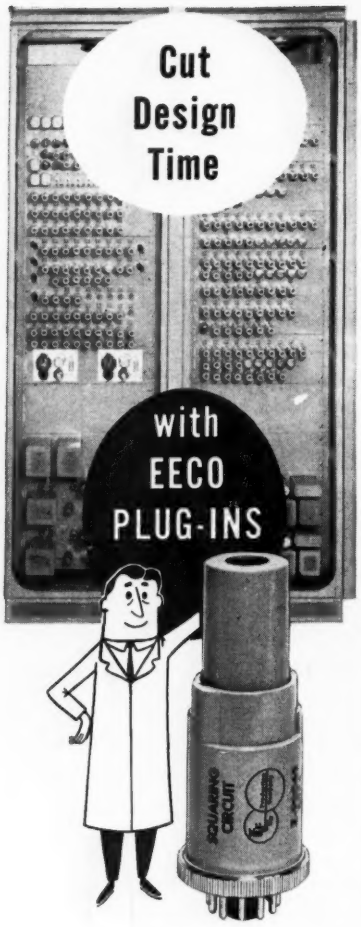
TYPE 416 UNIVERSAL FUEL NOZZLE TEST STAND

A complete testing "laboratory" designed and built by CRL for determining optimum efficiency of jet airplane fuel nozzles. Now in use by the U.S. Air Force and others. Other CRL products include Cox Calibrating Stands, Carburetor Flow Stands, Magnetic Thickness Gages, Balanced Electronic and Vibration Recording Equipment.



C R L

For more information circle **83** on inquiry card.



Step up engineering output by utilizing functional design technique and EECO plug-in circuits . . . use engineering time to design systems instead of circuit detail. These basic circuit units are already being used by scores of organizations as building blocks in developing electronic equipment with surprisingly large economies of engineering and fabrication time. Thoroughly proven by more than four years service in some of the nation's largest data systems, standard EECO plug-ins are available from stock. Custom units with your circuit can be readily manufactured, and costs are actually below those of standard assembly methods. Write for data file no. B-3.

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SANTA ANA, CALIFORNIA

For more information circle **84** on inquiry card.

NEW INSTRUMENTS

shake tests in slow motion, or for positioning a fixed image anywhere in vibration cycle. Phase and amplitude of vibration can be directly and continuously observed for detecting and eliminating destructive mechanical resonances.—*Chadwick-Helmuth Co., P. O. Box* 321, *Monrovia, Calif.*

For more information circle **271** on inquiry card.

ELECTRICAL TESTING

C-R OSCILLOSCOPE

New "Type 329-A" is characterized by extremely high precision measurement and wide-band operation from dc to 20 Mc while retaining outstanding features of maker's "Type 329." New features include dual BNC input

connectors which permit switching between signals without disconnecting; a gain-bandwidth which allows doubling deflection sensitivity at some sacrifice in bandwidth; a variable-rate notch which permits a sweep-rate increase of as much as 100 times within the notch on lower sweep ranges; and a sync shaper to assure proper synchronization at high sweep speeds when sync pulse is of longer duration than sweep.—*Technical Products Div., Allen B. Du Mont Labs, Inc.,* 760 *Bloomfield Ave., Clifton, N. J.*

For more information circle **272** on inquiry card.

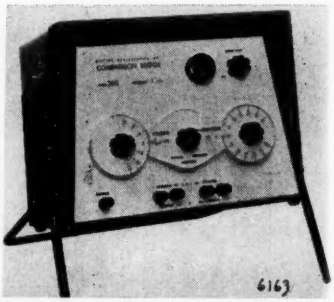
DUAL-BEAM C-R-O

New "Type 333" is a general-purpose dual-beam cathode-ray oscilloscope with complete and accurate calibration facilities and the same high sensitivity and high gain found in the most elaborate single-beam instruments. It employs a "Type 5-ARP" CRT whose tolerances are at least twice as stringent as those in a comparable single-gun tube. Tracking accuracy between beams is so high, interaction so low, and identical *Y* amplifiers so linear that signals can be superposed for direct comparison with negligible error. Other features include 16 full-scale ac or dc voltage ranges from 4 mv to 400 v; a 0-100 calibrated scale for direct readings of pressure, temperature, displacement, etc.; and variable illumination of scale.—*Technical Products Div, Allen B. Du Mont Laboratories, Inc., Clifton, N. J.*

For more information circle **273** on inquiry card.

COMPARISON BRIDGE

New "Model 260" is said to have been "humanly engineered for conveniently comparing" magnitude and

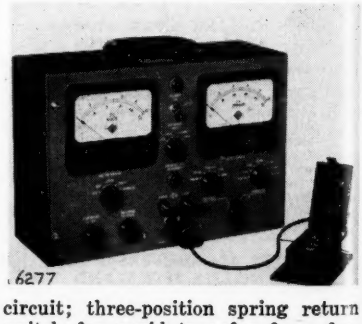


phase differences of resistive, capacitive and inductive components against a standard; was designed for laboratories where component matching to 0.01% is required but is as useful on production lines and on incoming materials.—*Electro-Measurements, Inc.,* 4312 *S. E. Stark St., Portland* 15, *Oregon.*

For more information circle **274** on inquiry card.

DIODE TESTER

New "Model DT-100A" for measuring static characteristics of diodes, features ammeter overload protective

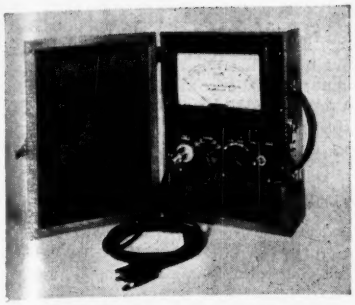


circuit; three-position spring return switch for rapid transfer from forward to reverse test positions; automatic overload circuit that detects shorted or reversed diodes and flashes a lamp while limiting current to a safe value. Optional: oven for testing diodes at elevated temperatures.—*Teletronics Lab., Inc.,* 54 *Kinkel St., Westbury, L.I., N.Y.*

For more information circle **275** on inquiry card.

LOW-RESISTANCE TESTER

New "Model LRO-1 Ohmmeter" retains all operating features and ranges of its higher priced counterpart,



"LEO," but is housed in rubbed hardwood case instead of costly gasketed metal case. Accuracy 1.5% of full scale reading. Ranges 0/0.1/1.0/10 ohms.—*Industrial Instruments, Inc., 89 Commerce Rd., Cedar Grove, N. J.*

For more information circle **276** on inquiry card.

GRID DIP METER

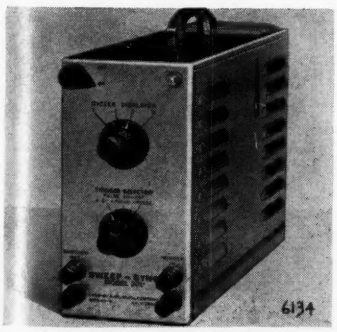
New "Model G-21" features 7 to 120 Mc measuring range, 5% accuracy, is hand-operated and powered by

standard hearing-aid batteries (or plug-in 110-v converter on special order). Finger-tip tuning offers maximum operating convenience.—*Alto Scientific Co., 855 Commerical St., Palo Alto, Calif.*

For more information circle **277** on inquiry card.

AUTOMATIC SAWTOOTH GENERATOR

New "Model 201 Sweep-Sync" produces linear horizontal sweep on CRO for display of a selected number of



cycles of vertical-axis signal. This number, once set, remains constant over sweep rates from 5 cps to 100 kc without need of adjustments for

transistor and
digital computer techniques

APPLIED TO THE DESIGN, DEVELOPMENT
AND APPLICATION OF

AUTOMATIC RADAR DATA PROCESSING,
TRANSMISSION AND CORRELATION
IN LARGE GROUND NETWORKS

Engineers
&
Physicists

Digital computers similar to successful Hughes airborne fire control computers are being applied by the Ground Systems Department to the information processing and computing functions of large ground radar weapons control systems.

The application of digital and transistor techniques to the problems of large ground radar networks has created new positions at all levels in the Ground Systems Department. Engineers and physicists with experience in the fields listed, or with exceptional ability, are invited to consider joining us.

FIELDS INCLUDE

TRANSISTOR CIRCUITS • DIGITAL COMPUTING NETS •
MAGNETIC DRUM AND CORE MEMORY • LOGICAL DESIGN •
PROGRAMMING • VERY HIGH POWER MODULATORS AND
TRANSMITTERS • INPUT AND OUTPUT DEVICES •
SPECIAL DISPLAYS • MICROWAVE CIRCUITS

Scientific and Engineering Staff

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AND DEVELOPMENT
LABORATORIES

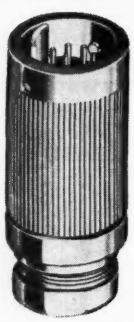
Culver City, Los Angeles County, California

IT

Are you working on a Miniaturization Program?

SUB*Minax*

Engineers working with rf equipment – oscilloscopes, amplifiers, bridges, scalers, etc. – should investigate space-saving, weight-saving Subminax rf connectors. Available in push-on or screw-on coupling, the Subminax line includes straight and angle plugs, cable and bulkhead jacks, receptacles and feed-throughs. There are also hermetically sealed receptacles in the screw-on design. Constant impedance – 50 or 75 ohms.



MINIATURE

AN-type CONNECTORS

Of particular interest to avionic engineers, 165 series Miniature AN-types are being used in production aircraft equipment in such applications as fuel indicators, gyro systems and auto-pilots. They replace standard ANs, giving the same dependable performance while contributing much smaller size and weight. 5, 9, 11, 12, 14 and 24 contacts. *Note:* plugs available in even smaller size for potting.

SUB*Minax* CABLE

Polyethylene, teflon or polyfluoron dielectric Subminax cables are available – all mate with Subminax connectors, provide the same dependable performance. Size? O.D.'s range from .100 to .145!

NOTE *Inquiries are invited for more specific information on* AMPHENOL *miniaturized components.*

AMPHENOL

AMERICAN PHENOLIC CORPORATION *chicago 50, illinois*
AMPHENOL CANADA LIMITED *toronto 9, ontario*

For more information circle **85** on inquiry card.

NEW INSTRUMENTS

changes in signal amplitude or frequency.—*Chadwick-Helmuth Co., P. O. Box* 321, *Monrovia, Calif.*

For more information circle **278** on inquiry card.

QUALITY-FACTOR TESTER

New "Q-Sweep," for rapid production-line *Q* measurements, displays *Q* by means of a 5% swept frequency,

thereby obviating need of resetting oscillator for each component test; can also be used as a *Q* meter by turning off sweep. Frequency range 20-220 Mc; range of *Q* measure 0-125/250; resonating capacitor range 7.5-100 mmf displayed digitally.—*Kay Electric Co.*, 14 *Maple Ave., Pine Brook, N. J.*

For more information circle **279** on inquiry card.

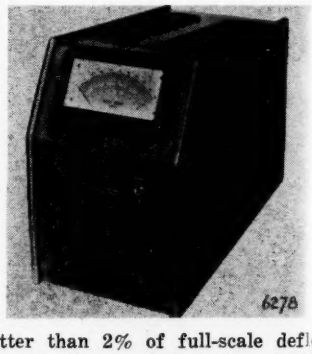
FM/AM RECEIVERS

Two new British-made "Eddystone" FM/AM receivers are for measurements in range 19 to 500 Mc. "Model 770R" covers 19 to 165 Mc; "Model 770U" 150 to 500 Mc. Each has six ranges (switched by means of an extremely rugged mechanism), highest possible order of stability, American tubes, all components fully tropicalized, excellent AGC characteristics, and each incorporates an S-meter and BFO.—*Marconi Instruments*, 44 *New Street, New York* 4, *N. Y.*

For more information circle **280** on inquiry card.

PULSE HEIGHT VTVM

New "PV-812" pulse-height vacuum-tube voltmeter (made by British Physical Labs) features accuracy of



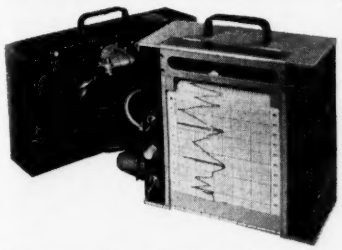
better than 2% of full-scale deflection; readings entirely independent of pulse width from 0.01 usec upward. Ranges: 0-/10/30/100 v.—*Television Accessories Co.*, 1412 *Great Northern Bldg., Chicago* 4, *Ill.*

For more inforination circle **281** on inquiry card.

ELECTRICAL INSTRUMENTS

MILLIVOLT RECORDER

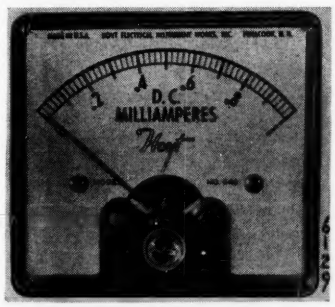
New portable recording millivoltmeter meets growing need for a junior-size instrument. Recorder and amplifier are in separate units with a total weight of 25 lb. Pen function is independent of inertial components in carborne and airborne use. Chart width 5"; chart speed 3" per min; pen speed ½ sec for full-scale travel.—*Well Tab Instruments, Inc., Box* 4007, *Santa Fe, N. M.*



For more information circle **282** on inquiry card.

MILLIAMMETERS

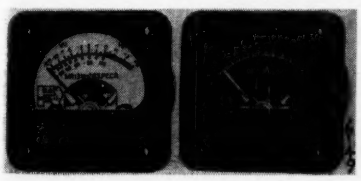
New "No. 649" (dc) and "No. 650" (ac) milliammeters feature low cost; clear polystyrene case; 2½" scale (20% longer than with standard Bakelite case); anti-static treated; virtually dust-tight; standard mounting dimensions.—*Burton-Rogers Co., Hoyt Electrical Instrument Works,* 42 *Carleton St., Cambridge* 42, *Mass.*



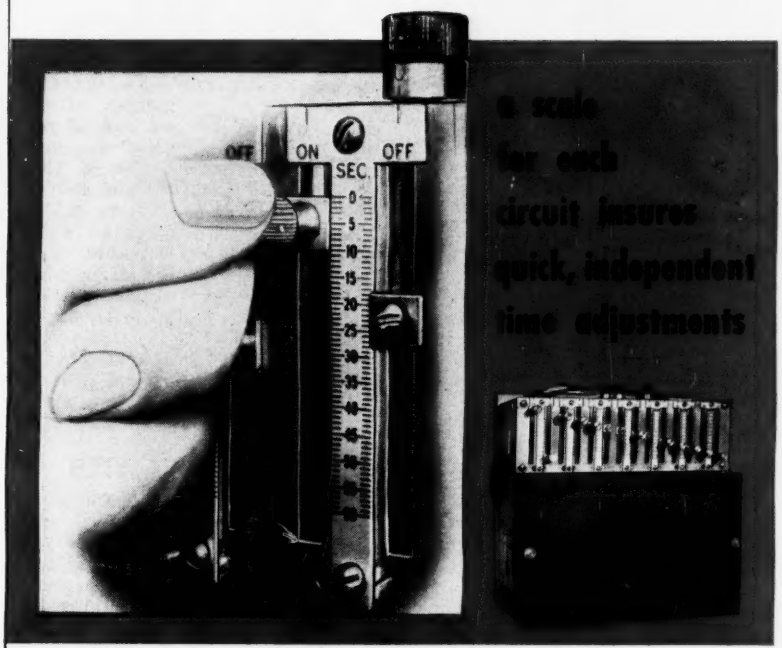
For more information circle **283** on inquiry card.

VU AND DB INSTRUMENTS

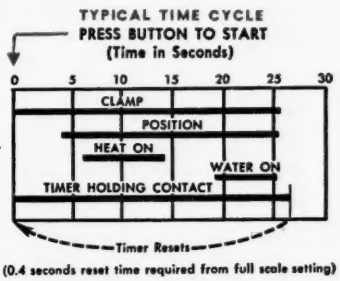
New 1½" VU and db panel instruments for audio system monitoring and radar equipment are ruggedized and conform to MIL-M-10304 and MIL-M 3823; are available in either square or round housings; meet size and weight reduction requirements in



EAGLE MULTIFLEX (multiple circuit) reset timer

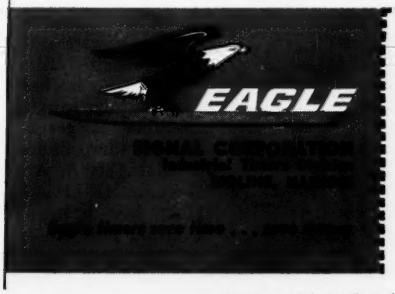


For controlling operation phases of electrically energized devices in processing work. The Multiflex Reset Timer closes and opens one to six circuits during a time interval started by push button, limit switch or other means. It's the only multiple circuit timer that provides a calibrated scale for quick, independent adjustment of each circuit. Time changes are made rapidly by moving a simple slide adjustment. Settings are possible to 1% of full scale. Vernier knobs are provided for use where more accurate settings are required. Multiflex Timers are available with time scales from 30 seconds to 5 hours. Send for free bulletin.



(0.4 seconds reset time required from full scale setting)

MAIL COUPON TODAY



EAGLE SIGNAL CORPORATION
Industrial Timers Division, Dept. IA-356
MOLINE, ILLINOIS

Please send Bulletin 130 containing full data on Multiflex Reset Timer.

NAME AND TITLE _____

COMPANY _____

ADDRESS _____

CITY _____ ZONE _____ STATE _____

For more information circle **86** on inquiry card.

NOW . . .
a DC Reference Voltage
That's Constant
from −55° to +100°C

K-Volt Standard*
Tubeless Constant Voltage Source
For Measurement & Control Circuits

Designed to replace the chemical cell and VR tube in airborne, laboratory and other critical instrumentation, the K-Volt Standard provides constant voltage through extremes of operating conditions . . . including ambient temperatures as low as −55° and up to 100°C. Operating from AC or DC supply, it employs no tubes or moving parts, is unaffected by position, vibration or mechanical shock. Negligible temperature coefficient, dependable regulation characteristics and rugged design make it applicable as an absolute reference, a constant output working supply, or a precision voltage regulator wherever specifications demand highest stability. Other important features are:

- Small size: 1½" by 1¼" dia.
- Power drain less than 1.8 watts
- Life: more than 10,000 hrs.
- Vibration: conforms to MIL-E-5272A
- Miniature 7-pin base
- Weight: less than 3 oz.
- Hermetically sealed
- Random drift less than 0.1% over 1000 hrs.

Models to Meet Wide Range of Application Requirements: The K-Volt Standard is available for operation from 26.5 volts DC, or 117 volts AC, 60 or 400 cycles; DC output 6 volts or 1 volt, at 1 ma or 10 ma.

For complete specifications and performance data send for bulletin No. K128

*TRADE MARK

AVION
Precision Instruments and Control Systems
58-15 Northern Blvd., Woodside 77, N. Y.

For more information circle 87 on inquiry card.

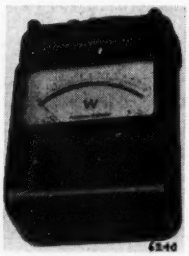
NEW INSTRUMENTS

aircraft and electronic equipment subject to shock vibration or temperature extremes.—*DeJur-Amsco Corp.*, 45-01 *Northern Blvd., Long Island City* 1, *N. Y.*

For more information circle **284** on inquiry card.

PRECISION WATTMETER

New Goerz (Vienna) low-power precision wattmeter has current ranges of 10 ma and 50 ma and voltage ranges of 150, 300 and 450 v; accuracy 0.5%; particularly suitable for measuring power consumption in coils, etc.—*Physics Research Labs., Inc.*, 507 *Hempstead Turnpike, West Hempstead, N. Y.*



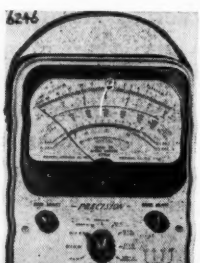
For more information circle **285** on inquiry card.

MICROVOLT-AMMETER

New "Model 203 DC Microvoltmeter-Ammeter" can measure voltages as small as 10 microvolts and currents as small as one micromicroampere. Fifteen voltage ranges from 100 uv full-scale to 1000 v full scale; ten current ranges from 100 uua to 100 ma. Operating principle: small signal to be measured is amplified by chopper amplifier, rectified and applied to a precision microammeter. Unit is handy as a recorder preamplifier and can be used as an impedance transformer between high-impedance sources and low-impedance indicating devices.—*Kay Lab., Box* 16, *San Diego* 12, *Calif.*

For more information circle **286** on inquiry card.

VT VOLT-OHMMETER



New "Model 78" moderately-priced battery-operated vacuum-tube volt-ohmmeter is said to be a "wide-range general purpose electronic test set." It is equipped with 1% multipliers and shunts of both wire and deposited-film types. It has six true-zero-center dc voltage ranges to 1500 v, five resistance ranges to 1000 megs, five extra-high-impedance rms ac voltage ranges to 1200 v. Accessories available include HF crystal probe and HV safety test probe.—*Precision Apparatus Co., Inc.*, 70-31 *84th St., Glendale* 27, *L.I., N.Y.*

For more information circle **287** on inquiry card.

CAVITY WAVEMETERS

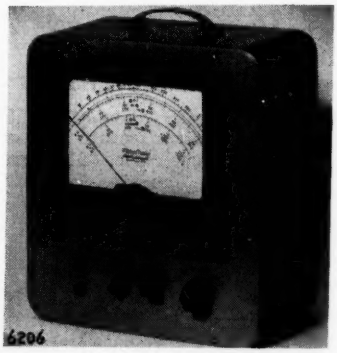
New line of precision cavity wavemeters gives unusually broad coverage of microwave bandwidths: eleven

sizes serve entire range from 2.6 to 90 kMc. Accuracy is so high that units can be used as secondary standards for "calibrating all other laboratory cavities." Sealed construction, together with ball bearing and nitrogen gas pressurization, assure permanence of calibration and maintenance of *Q* values for many years without service.—*DeMornay-Bonardi*, 780 *So. Arroyo Parkway, Pasadena, Calif.*

For more information circle **288** on inquiry card.

VACUUM-TUBE VOLT-OHMMETER

New "Meter-Matic" features automatic range switching. Application of the probes to points being checked



gives an immediate reading on 8½" indicator. Scale to be read is indicated by a recessed red light. Ranges 0.1 v to 1500 v, 0.5 ohm to 1000 megs.—*Leitch Engineering Corp., Manchester, N. H.*

For more information circle **289** on inquiry card.

MOTOR LOAD INDICATOR

New "MEK-2127" has advantages over conventional ammeter: (1) Easy-to-read scales calibrated in either percent load or horsepower with large color bands to show at a glance how machine is performing. (2) Highly damped instrument. (3)

Conversion unit can be mounted near motor starter and light control wires can be connected to indicator.—*Machinery Electrification, Inc., Northboro, Mass.*

For more information circle **290** on inquiry card.

ELECTR-INSTRUMENT ACCESSORIES

HIGH-PRECISION CAPACITOR

New "Model 2160" worm-driven air capacitor meets rigid requirements of instrument manufacturers; is reset-

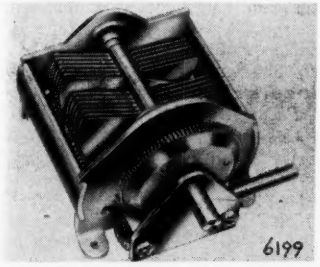
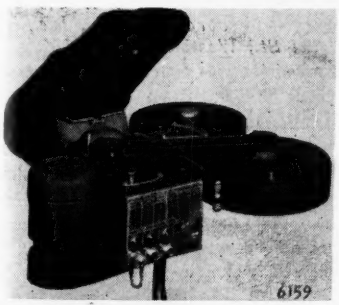


table to 0.002%. Proper combination of materials has reduced temperature coefficient to practically zero. Capacitance variation is linear with a maximum of 300 mmf per rotor-stator element; unit can be connected for 150, 300, or 600 mmf maximum capacitance.—*Johanson Mfg. Corp., Boonton, N. J.*

For more information circle **291** on inquiry card.

C-R-O CAMERA

New "Type 321-A Continuous-motion-film Oscillograph Record Camera" features high resolution film im-



ages without distortion regardless of aperture setting; uses easily-obtainable 35-mm film in magazines; has electrical connections for remote operation; can be quickly turned on its side to permit recordings plotted along a vertical axis.—*Technical Products Div., Allen B. Du Mont Labs, Inc., 760 Bloomfield Ave., Clifton, N. J.*

For more information circle **292** on inquiry card.

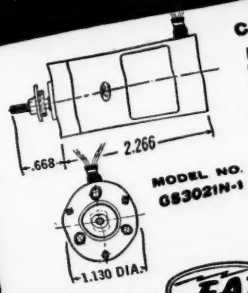
SWITCHING AND BALANCING UNITS FOR PICKUPS

Three new models of SR-4 switching and balancing units for use with resistance wire strain gages: "PSBA-

power
in a pillbox

EAD's
new miniaturized
1⅛ inch
servo-gear motor

For instant response and maximum torque in a miniature package it's EAD's tiny servo-gear motor, precision-designed for applications where size and weight are at a premium. Modifications available in hysteresis-synchronous and induction designs . . . Tell us your requirement.
Write for our new catalog.



MODEL NO. 6S3021N-1

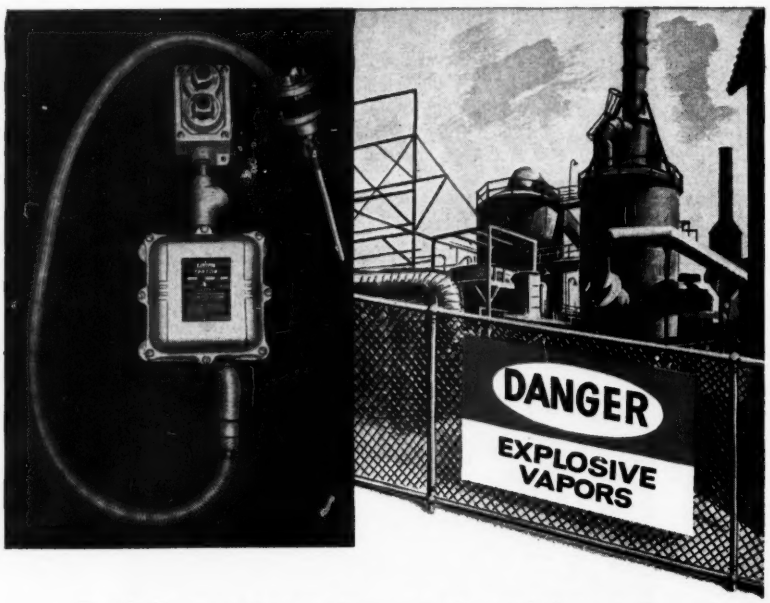
CHARACTERISTICS	
Input Voltage	115
Phase	2
Frequency	400 cycles
No Load Speed	180 rpm
Full Load Speed	135 rpm
Rotor Inertia	1.25 gm. cm²
Stall Torque	7 oz. in.
Rated Torque	3 oz. in.
Size	1 1/8" dia. 2 17/64" long
Gear Reduction	28.4
Weight	4 1/2 oz.
Duty	Continuous

EAD
EASTERN AIR DEVICES, INC.
SOLVING SPECIAL PROBLEMS IS ROUTINE AT EAD

347 CENTRAL AVE., DOVER, NEW HAMPSHIRE

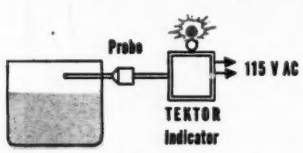
For more information circle **88** on inquiry card.

TEKTOR Electronic Level Control now approved for hazardous areas



Practically every plant can improve level control electronically—and meet safety requirements—now that the entire Fielden TEKTOR System is UL listed and FM approved for Class I, Groups C and D, and Class II, Groups E, F and G, hazardous locations.

This explosion-proof unit features a specially-designed ferralloy housing and Teflon* insulated probe. Available for fail-safe high or low level control, it now brings the simplicity and versatility of capacitance circuitry to areas free of acetylene, hydrogen, or equally hazardous gases.



As level changes, capacitance at the probe also changes and energizes a relay. TEKTOR flashes a warning and can operate controls to keep level from exceeding desired limit.

TEKTOR features

- Controls level of liquids, liquid interface, powders, granular solids (conducting or non-conducting)
- Responds to changes as small as 1/16" in aqueous solutions
- No moving parts—only one radio tube

Robertshaw-Fulton CONTROLS COMPANY

*Trade-mark for Du Pont tetrafluoroethylene resin.

FIELDEN INSTRUMENT DIVISION
Dept. A, 2920 N. 4th St., Philadelphia 33, Pa.

Please send me the following bulletins:

- ☐ TEKTOR Level Limit Control
- ☐ TELSTOR Continuous Level Indicator
- ☐ TEKTOLOG Recorder-Controllers
- ☐ NULL-BALANCE Recorders-Controllers
- ☐ SCANNERS
- ☐ MULTI-POINT Recorders

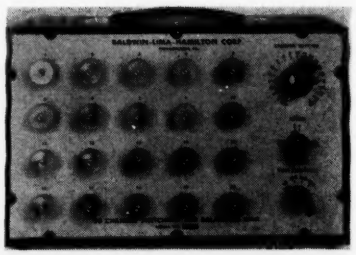
NAME_____ TITLE_____

COMPANY_____ ADDRESS_____

CITY_____ ZONE_____ STATE_____

For more information circle **89** on inquiry card.

NEW INSTRUMENTS



20" and "PSBA-12" 20-channel and 12-channel switching and balancing units, and "PSA-20" 20-point switching unit. New features include four-position switch for resistance of 60, 120, 350, and 500 ohms.—*Baldwin-Lima-Hamilton Corp., Philadelphia 42, Pa.*

For more information circle **293** on inquiry card.

ELECTRONIC SWITCH

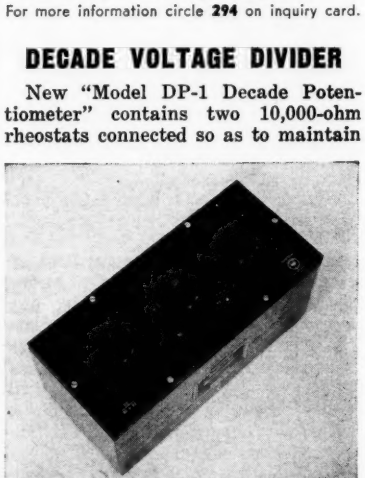
New "Model ES-180A" provides dc to 15 Mc dual trace presentations on any conventional 'scope at switching

rates up to 400 kc; features movable horizontal index and provisions for introducing time markers. Control dial, calibrated in both volts and percent, allows absolute and relative amplitude measurements to 2% accuracy.—*Teletronics Lab., Inc., 54 Kinkel St., Westbury, L.I., N.Y.*

For more information circle **294** on inquiry card.

DECADE VOLTAGE DIVIDER

New "Model DP-1 Decade Potentiometer" contains two 10,000-ohm rheostats connected so as to maintain



a total resistance of 10,000 ohms at all times. Resistance between center and either end is variable from 0 to 10,000 ohms, while that between center and opposite end makes up the difference to total 10,000 ohms. Ratio is in-

dicated directly on dials of decades. Ratios of 0.000 to 1.000 in steps of 0.001 are guaranteed to 0.1% at all settings above 0.01.—*Industrial Instruments, Inc., 89 Commerce Rd., Cedar Grove, N. J.*

For more information circle **295** on inquiry card.

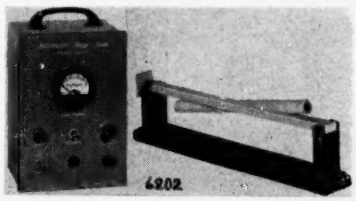
DECADE CAPACITOR

New "Model 100" has a range of 0 to 10 ufd in 1-ufd steps. Standard tolerance 10%, closer tolerance on special order. Unit is designed for use in wave filters, equalizers, tuned circuits, etc.—*High Fidelity Products, Box 131, Owensboro, Kentucky.*

For more information circle **296** on inquiry card.

RANDOM NOISE SOURCES

New "Mega-Nodes," calibrated random noise sources for microwave frequencies, utilize fluorescent tubes only



and cover these frequency ranges: "WR 770" 960-1450 Mc; "WR 650" 1120-1700 Mc; "WR 510" 1450-2200 Mc; "WR 430" 1700-2600 Mc; "WR 340" 2200-3300 Mc. Noise output (all guides) 15.8 db; accuracy 0.25 db.—*Kay Electric Co., 14 Maple Ave., Pine Brook, N. J.*

For more information circle **297** on inquiry card.

AMPLIFIERS

INDUSTRIAL SERVO AMPLIFIER

New "Model 1120 Servoflex," designed specifically for industrial control systems, is a 60-cps two-phase motor control with built-in summing network; will accept from one to three ac inputs; will drive any 10-watt two-phase servomotor; can be used either in a position servo system (providing tachometer stabilization to minimize overshoot and hunting) or velocity servo (with linearity and extended proportionality range of control motor speed).—*Servo Corporation of America, 20-20 Jericho Turnpike, New Hyde Park, L. I., N. Y.*

For more information circle **298** on inquiry card.

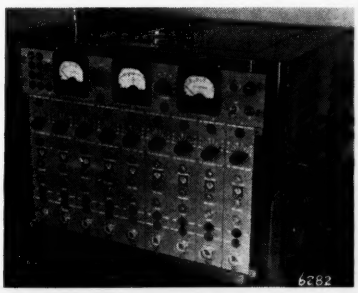
WIDEBAND AMPLIFIER

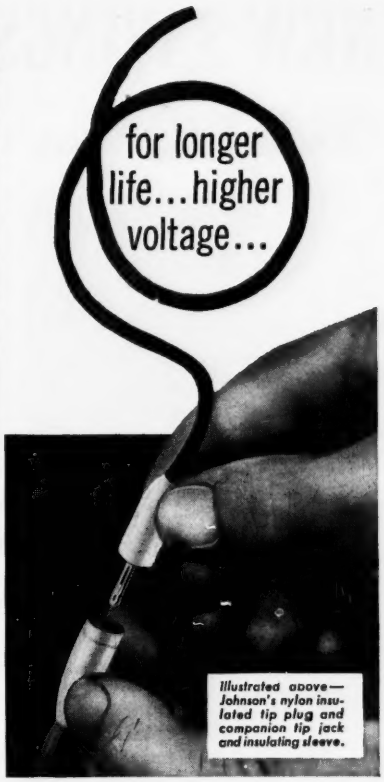
New "Model 720" is a feedback stabilized wideband amplifier for use in amplifying fast pulses in nuclear research, TV, transient studies, etc. Bandwidth from below 2,000 cps to 10 Mc; gain continuously variable by coarse and fine attenuators from 60 db (max) to 20 db (min); output up to 50 v pulses into a 1500-ohm load or 10 v into a 200-ohm load. Input polarity switch allows either positive or negative input pulses to appear as positive output pulses.—*Electrical and Physical Instrument Corp., 42-19 27 St., Long Island City 1, N. Y.*

For more information circle **299** on inquiry card.

MULTICHANNEL AMPLIFIER

New multi-channel dc amplifier consists of a closely-regulated multivoltage power supply and nine stable high-gain amplifiers. Originally for oscillographs, can also be used for driving recording galvanometers directly from thermocouples, measuring small signals, checking photocell outputs, amplifying strain-gage outputs, etc. Frequency response for each amplifier is dc to 25,000 cps (within




for longer life...higher voltage...
Illustrated above—Johnson's nylon insulated tip plug and companion tip jack and insulating sleeve.

Solderless Nylon Connectors

(Available in 11 bright colors)

- Shock-proof nylon sleeves—won't chip or crack with the hardest usage.
- Excellent for high voltage applications.
- Highly resistant to extremes of heat, cold and moisture.
- Tip and banana plugs designed for simplified solderless connection of up to 16 gauge stranded wire.
- Economical—simple, functional design gives you top quality at low cost.

SPECIFICATIONS

BANANA PLUG—Nickel-plated brass construction with nickel-silver springs. Spring plug is .175" diameter, fits all standard banana jacks.

TIP PLUG—Recessed metal head is fully insulated. Metal parts are brass, nickel-plated. Pin is .081" diameter—fits all standard tip jacks.

NYLON TIP JACK AND INSULATING SLEEVE—Complete assembly includes standard nylon tip jack with threaded nylon insulating sleeve. Ideal for patch cords or for panel mounting where an insulated rear connection is desired.

Write for samples, prices and further information.

Pilot Lights

Available in a wide variety of types, Johnson Pilot Lights are stocked by parts distributors throughout the country. Available types include: continuous indication neon types; models for high and low voltage incandescent bulbs; standard or wide angle glass and lucite jewels in clear, red, green, amber, blue, or opal lenses. Specials, including those meeting military specifications are also available in production quantities. For full information, write to:

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For more information circle **90** on inquiry card.

NEW SAVINGS in your operations

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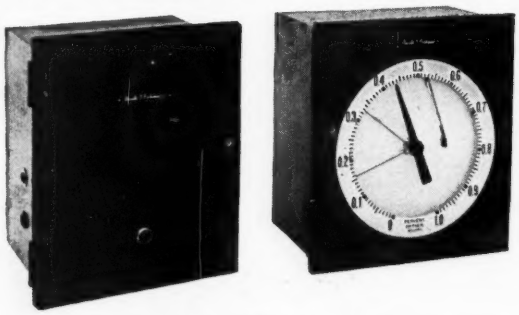
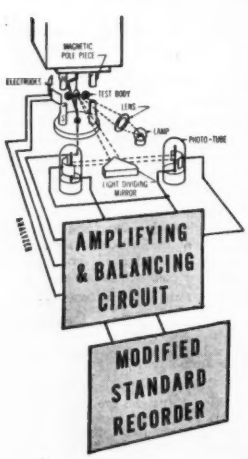


Pictured is the Model G2 Recording Analyzer—finest for precise oxygen measurement.

ON OPERATIONS LIKE THESE... MAKE SAVINGS LIKE THESE

PROCESSING AIR LIQUIFRACTION AND PRODUCTION OF HIGH PURITY GASES	*Better product quality with minimum oxygen or air contamination*
SAFETY PRODUCTION OF HYDROGEN, ACETYLENE, ETC.	*Control explosive atmospheres, reduce fire risks, minimize plant and personnel hazards*
PRODUCT PROTECTION RESIN KETTLES, COLOR PIGMENTS, PRODUCT STORAGE, ETC.	*Reduce oxidation, maintain product standards with controlled purge systems*



Unique Operating Principle

The various applications highlighted above are only a few of the many ways Arnold O. Beckman Oxygen Analyzers—industry's great new profit builders—are being used by progressive operators to boost profits, cut costs.

These are the *only* oxygen analyzers that *continuously* measure process streams by an advanced magnetic principle that provides *direct physical measurement of the oxygen itself*—not of some secondary relationship.

Heart of the unit, as illustrated, is a dumbbell-shaped test body suspended in a magnetic field. Sample gas surrounding this test body causes it to rotate in the field, depending upon the oxygen content of the gas. The movement of a light beam, reflected by a small mirror on the test body, is measured by simple electronic circuits... and the result indicated directly on a conventional recorder or indicator. It's simple, positive, accurate!

No chemicals—filaments—catalysts cams—complicated mechanical parts!

***Send for Helpful Free Literature** which describes this unique operating principle in detail—explains its many advantages and applications. When writing, outline your particular operations—we'll gladly supply specific information.*

Ask For Data File 15G-26

FEATURES OF THE G2

Many ranges: Full scale ranges 0-0.1%, 0-0.5%, 0-1% O_2 and others for low O_2 concentrations. Ranges 90-100%, 95-100% O_2, etc., for high O_2 concentrations.

Multi-Ranges: Any instrument may be supplied with two or more ranges.

Note: For ranges wider than 0-5% O_2, ask about the Model F3 Analyzer.

Arnold O. Beckman INC

Instruments for Science and Industry

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For more information circle 91 on inquiry card.

1%); gain 1100 per channel; input range selector for eight ranges from 0.05 to 8 volts per inch of galvanometer deflection.—*United Control Corp., 4540 Union Bay Pl., Seattle 5, Wash.*

For more information circle **300** on inquiry card.

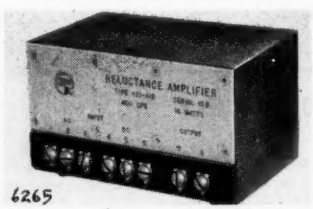
STRAIN GAGE AMPLIFIER

New "Model 110" chopper-stabilized broadband dc amplifier has a long-time drift (40 hours) of 2 microvolts; equivalent input noise is less than 5 uv peak-to-peak for 3-cps bandwidth, less than 5 uv rms for 750-cps bandwidth and less than 12 uv rms for 50-kc bandwidth. Variable gains up to 1000 accurate to 1%. Bandwidth flat within 3 db from dc to 30 kc. Output 25 volts with a 1000-ohm load; linearity better than 0.1%.—*Kay Lab., Box 16, San Diego 12, Calif.*

For more information circle **301** on inquiry card.

SERVO AMPLIFIER

New "Model 1121 Servoflex" is a small lightweight reluctance type servo amplifier which accepts two ac in-



puts and one dc input in any combination. With instantaneous response (time lag negligible compared to one cycle of supply frequency), it produces proportional and reversible power output for most 115-v 400-cps servomotors rated at 18 watts or less. —*Servo Corporation of America, 20-20 Jericho Turnpike, New Hyde Park, L.I., N.Y.*

For more information circle **302** on inquiry card.

SERVO AMPLIFIERS

New magnetic servo amplifiers are designed for use as power amplifier output stages for control of 400-cps 2-phase servomotors. Output is sinoidal, variable in amplitude, and phase-reversible. Input control signals can

be either ac or dc. No dc power supplies are needed for operation of new units and their transistor or tube control circuit. Standard output ratings 3, 6, 10, 16 and 40 watts.—*Timely Instruments & Controls Corp., 1645 W. 135th St., Gardena, Calif.*

For more information circle **303** on inquiry card.

POWER SUPPLIES, etc.

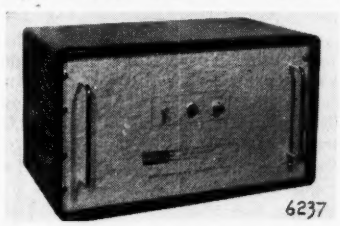
TUBELESS D-C SUPPLY

New "Model G101F Aircraft Battery Eliminator" provides 0-20 vdc @ 0-10 amp for ground operation and bench testing of airborne equipment; operates entirely without electronic tubes; features large ammeter and voltmeter and an ammeter protection circuit which prevents danger of needle slam during periods of high in-rush current.—*Gates Electronic Co., 611 Morris Park Ave., Bronx, N. Y.*

For more information circle **304** on inquiry card.

A-C LINE REGULATOR

New "Model MLR 1000" magnetic-amplifier-regulated 1-kva tubeless ac line voltage regulator contains no



moving parts or vibrating contacts. Nominal 115-v output can be adjusted from 110 to 120 v; regulation accuracy 0.25% for any combination of line or load.—*Perkin Engineering Corp., 345 Kansas St., El Segundo, Calif.*

For more information circle **305** on inquiry card.

D-C SUPPLY REGULATOR

New "Model 2 300-Volt D-C Power Supply Regulator" was designed specifically for those applications where high-performance electronic equipment is being developed. All transformers and chokes have grain-oriented core material and are hermetically sealed (MIL-T-27), extra-heavy front-end filtering. Output has less than ⅓ mv of combined ripple and jitter; loads from zero to 1 amp at 300 v nominal. Dimensions 10½" H, 19" W, 13" D; weight 86 lbs.—*Eastgap Co., 285 Columbus Ave., Boston 16, Mass.*

For more information circle **306** on inquiry card.

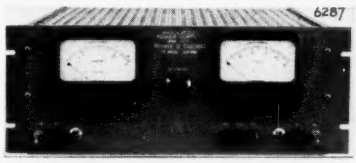
DUAL-OUTPUT REGULATOR

New "EE100 Distortion Eliminating Voltage Regulator" is expressly designed to eliminate disturbing harmonics and low-frequency noise in 115-v 60-cps power sources. It furnishes: (A) 1.4 kva of ±1% voltage-regulated power with line distortion reduced to less than 0.3%; recovery time less than 1/50 cycle; no phase shift between input and output. (B) 4 kva of ±1% regulated power for applications where normal line distortion and slower voltage regulation can be tolerated.—*Component and Instrument Dep't, Curtiss-Wright Corp., 631 Central Ave., Carlstadt, N. J.*

For more information circle **307** on inquiry card.

TRANSISTOR SUPPLY

New "Model C-22-2," specifically designed for use in development of power transistor circuits, delivers 0-



30 v and 0-2 amp. Regulation better than 0.1 v; ripple less than 2 mv; output voltage response time about 100 usec; internal impedance 0.05 ohm on dc.—*Universal Electronics Co., 22nd St., Santa Monica, Calif.*

For more information circle **308** on inquiry card.

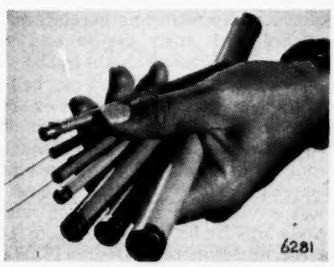
KLYSTRON POWER SUPPLY

New "Model TVN-11B" provides up to 75 ma beam current at 225 to 500*u*, with both beam and reflector voltages continuously variable. Other features include both square wave and sawtooth modulation—square wave with minimum overshoot and sawtooth with good linearity for driving an external instrument; reflector voltages from 25 to 875 with better than 1% regulation and better than 2.5 mv ripple content on both beam and reflector voltages. Instrument is housed in a gray rack mount cabinet; can be used either in a rack or in cabinet.—*Browning Laboratories, Inc., 750 Main St., Winchester, Mass.*

For more information circle **309** on inquiry card.

SELENIUM RECTIFIERS

New "Selenium Slims," especially developed for high-voltage low-current applications, are small disc-type



tubular rectifiers, available in sizes from ⅛" to ½" dia; in assemblies of

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For more information circle **92** on inquiry card.

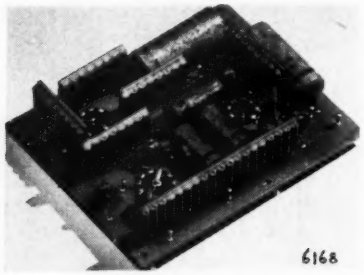
up to 200 cells. Ratings: 1, 2½, 5, 10 and 20 ma dc per cell in a half-wave circuit using a condenser input filter at maximum ambient temperature of 35°C. Reverse voltage rating 26 v rms per cell.—*Union Switch & Signal, Div., Westinghouse Air Brake Co., Pittsburgh* 18, *Pa.*

For more information circle **310** on inquiry card.

ELECTRICAL & ELECTRONIC COMPONENTS

GRAPHIC-CIRCUIT SUBASSEMBLIES

New "PAC Modules" are said to represent a revolutionary development. Illustration shows a printed



circuit board after conversion to "PAC Modules." Sixteen units are said to do the work of 69; in other words, six "PAC" units replace 59 conventional components.—*Erie Resistor Corp., Erie* 6, *Pa.*

For more information circle **311** on inquiry card.

SEALED DELAY LINES

New standard single-stick hermetically-sealed delay lines are in 0.4" OD brass tubing with condenser end-seals; are commonly mounted in a fuse-clip or with a cable-clamp. Three designs available in each impedance level and delay time: One design emphasizes maximum delay per cu in with fair rise time. Second combines moderate delay per cu in with good rise time. Third emphasizes fast rise time with low delay per cu in. Most units are carried in stock for immediate shipment. —*PCA Electronics Inc.*, 2180 *Colorado Ave., Santa Monica, Calif.*

For more information circle **312** on inquiry card.

MINIATURE PULSE TRANSFORMER

New highly-miniaturized "MPT" is available in 2, 3, and 4 windings, and a pulse width range of 0.01 to 25 usec

(other values available); meets MIL-T-27A wherever applicable. Most designs are available for immediate shipments. Prices are said to be "the lowest in the industry."—*PCA Electronics Inc.*, 2180 *Colorado Ave., Santa Monica, Calif.*

For more information circle **313** on inquiry card.

P-N-P TRANSISTOR

New "2N138" miniature *p-n-p* fused junction germanium transistor, for push-pull class B audio output applications, is sold only in pairs matched for optimal output and minimal distortion. In a typical application using a 4.25-v supply, average power output is about 50 mw with power gain of 30 db.—*Raytheon Mfg. Co.*, 55 *Chapel St., Newton* 58, *Mass.*

For more information circle **314** on inquiry card.

SINGLE-TURN VDR

New "SI-9000" single-turn continuous-mechanical-rotation voltage-dividing resistor features low noise level; is gangable to a total of 14. Mechanical rotation 360°; electrical rotation, 352±50; resistance range 5 ohms to 25 k; standard resistance tolerance 10%; rating 0.8 watt.—*General Scientific Corp. Div., San Fernando Electric Mfg. Co., San Fernando, Calif.*

For more information circle **315** on inquiry card.

HIGH-RATING CAPACITORS

New drawn oval air-conditioner running capacitors, rated up to 20% above present units with the same cross section, are designed to help manufacturers meet Underwriters' Laboratories 1956 requirements for room air conditioners.—*General Electric Co., Schenectady* 5, *N. Y.*

For more information circle **316** on inquiry card.

CRYSTAL FILTERS

New quartz crystal filters are synthesized by a new technique said to resolve many problems heretofore associated with their design and production, eliminating high initial cost and long lead time. Filters can be produced on short notice in large or small quantities to meet exact performance requirements; example, any frequency from 10 kc to 10 Mc, with attenuation characteristic tailored to meet almost any desired specification within bandwidth limits from 0.01% to 14% of center frequency.—*Hycon Eastern, Inc.*, 75 *Cambridge Parkway, Cambridge* 42, *Mass.*

For more information circle **317** on inquiry card.

DEPOSITED-CARBON RESISTORS

New line of deposited carbon resistors is said to feature accuracy and dependability combined with competitive price, 100% final inspection for resistance value and noise. Units are available for short-term delivery in a wide range of standard RETMA ohmage values and are produced in seven conservative ratings from 0.5 watt to 2 watts. Standard tolerances are 2%, 5% and 10%; special tolerances can be supplied.—*Electroseal Products, Inc.*, 22 *E. 40th St., New York* 16, *N. Y.*

For more information circle **318** on inquiry card.

RIB-WOUND RESISTORS

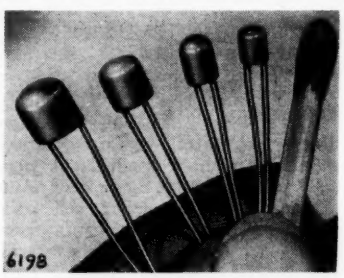
New power resistors feature corrugated edgewise wound ribbon wire, giving greater cooling area than tubu-

lar resistors of equal size. High thermal conducting vitreous enamels permit operation at high temperature rise without deterioration or damage. Standard available units up to 2,000 watts and up to 200 ohms.—*Reon Resistor Corp.*, 117 *Stanley Ave., Yonkers, N. Y.*

For more information circle **319** on inquiry card.

SUBMINIATURE DIODES

New subminiature selenium diodes, "Types 6UI, 7UI and 8UI," provide bias for tubes in commercial and mili-



tary electronic equipment that must withstand severe environmental conditions. "6UI" is rated for a maximum input of 156 v rms, "7UI," 182 v rms and "8UI," 203 v rms at 1.5 ma. All operate in ambient temperatures from −50°C to 100°C.—*International Rectifier Corp.*, 1521 *E. Grand Ave., El Segundo, Calif.*

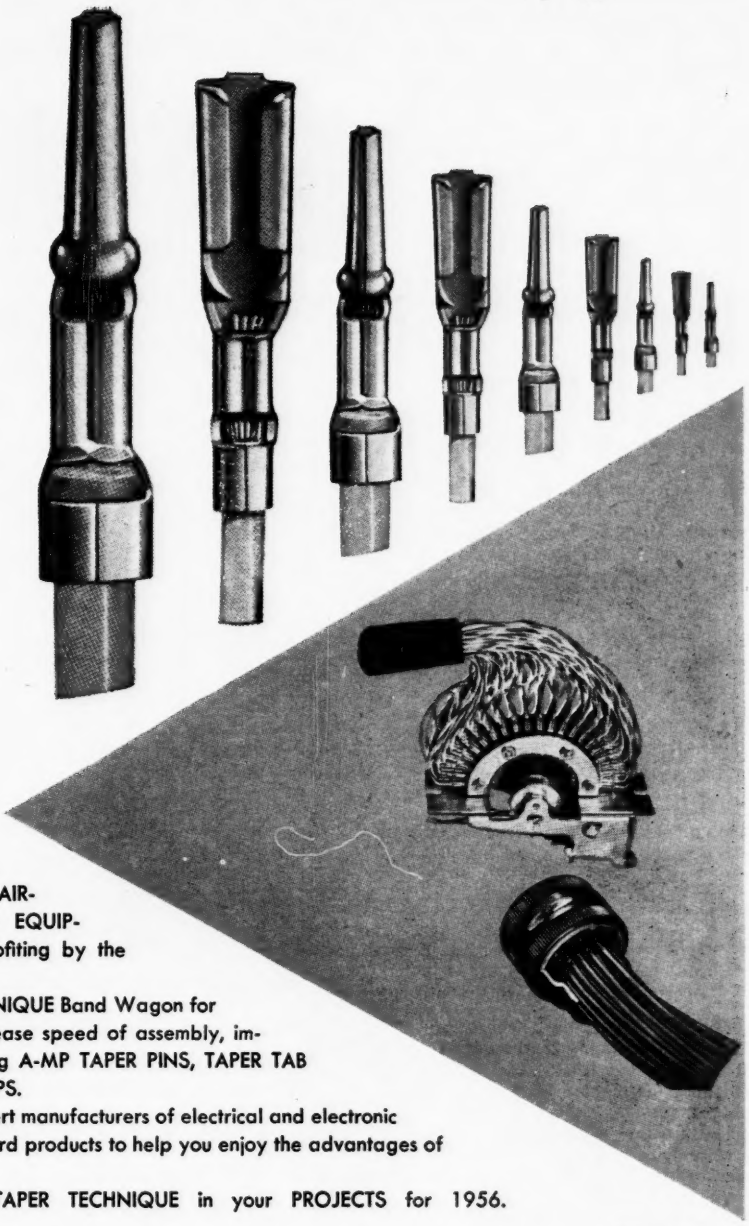
For more information circle **320** on inquiry card.

IMPROVED RECTIFIER

New "Rectalloy" rectifier utilizes a new rectifier alloy which retains advantages of copper-oxide rectifier but will permit smaller rectifier units. It has the same current rating as former copper-oxide rectifiers, but has a higher voltage rating per cell. This requires fewer cells in series,

project for '56

join the AMP® taper parade



Are you in step with the more progressive manufacturers of BUSINESS MACHINES—AIRCRAFT—GUIDED MISSILES—ELECTRONIC EQUIPMENT—who have approved and are profiting by the use of A-MP TAPER TECHNIQUE?

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For more information circle **93** on inquiry card.

lowers forward resistance and results in better voltage regulation. Its voltage drop is about two-thirds that an equivalent-rated selenium rectifier, whence reduced internal losses and higher operating efficiency.—*Union Switch & Signal Div., Westinghouse Air Brake Co., Pittsburgh 18, Pa.*

For more information circle **321** on inquiry card.

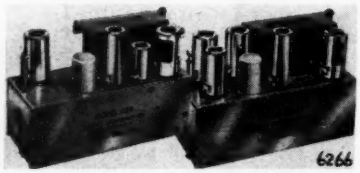
POWER RECTIFIER

New "NS-P1" silicon power rectifier will operate at ambient temperatures up to 200°C; "will deliver more power at high temperatures than any other rectifier of comparable size on the market," it is said. Shock- and vibration-proof case measures about 1-⅛" diam by 1-¼". Maximum reverse working voltage is 60 v and minimum Zener (breakdown) voltage is 70 v. Forward current density at 1 v drop is over 600 amp per sq in of junction area.—*Hoffman Electronics Corp., 3761 So. Hill St., Los Angeles 7, Calif.*

For more information circle **322** on inquiry card.

HIGH-ALTITUDE AMPLIFIERS

New "Servoflex Models 1123 and 1124," for high-altitude servo systems, meet MIL-E-5400; are lightweight



plug-in units featuring built-in preamplifier and built-in power supply. With instantaneous response, "1123" accepts 400-cps reversible input; "1124" accepts a single dc input or takes difference between two such inputs and a built-in 400-cps synchronous chopper modulates dc to ac. Both models will drive any 115-v 400-cps servomotor rated at 8 watts or less.—*Servo Corporation of America, 20-20 Jericho Turnpike, New Hyde Park, L.I., NY.*

For more information circle **323** on inquiry card.

oil, water, or fire-resistant hydraulic fluid. Square shape requires minimal space in application. Mounting can be made on any six faces of 14 mounting models. Four shaft-style models available.—*Roto-Mation Motors, Inc., 525 So. Riverside, St. Clair, Mich.*

For more information circle **327** on inquiry card.

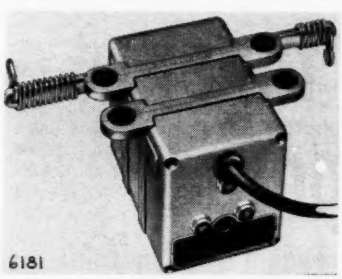
INSTRUMENT MOTORS

New hysteresis synchronous motors for precision instruments measure 3-7/32" diam by 2-23/32" long excluding shaft; deliver 5 to 6 oz-in of torque at constant speed. Three models: 600, 1200 and 1800 rpm. All are self-cooled and can be supplied with single- or double-ended shafts.—*Technical Development Corp., 4060 Ince Blvd., Culver City, Calif.*

For more information circle **328** on inquiry card.

LINEAR POWER UNIT

New #311-R Safe Return Motor" converts power taken from a pair of high-speed induction motors into



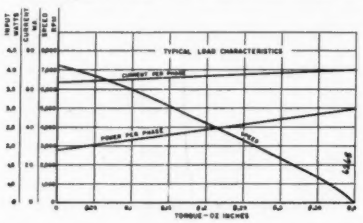
straight-line motion through a rack-and-pinion system. Because of dual motors, unit provides a power stroke up to 12", on both forward and return strokes. It will lift about 25 lbs a distance of 4" in 30 sec. There is no internal switching mechanism: direction-reversing switch can be mounted remotely; or unit can be commanded by a thermostat or timing device.—*Gleason-Avery, Inc., Auburn 1, N. Y.*

For more information circle **329** on inquiry card.

ELECTROMECHANICAL COMPONENTS

400-CPS SERVOMOTOR

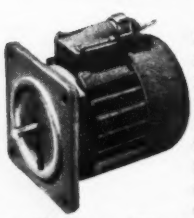
New "Type 17 I" miniaturized (1$\frac{1}{16}$" dia) servomotor weighs 3 oz; is designed for a minimum life of



1000 hours continuous operation at 150°C ambient temperature (tests indicate expected life of 200 h con op at 180°C ambient). Said to be ideal for use in high-speed aircraft and missiles where external cooling is not practical.—*Components Div., Servomechanism, Inc., 625 Main St., Westbury, L. I., N. Y.*

For more information circle **324** on inquiry card.

AIRCRAFT MOTOR

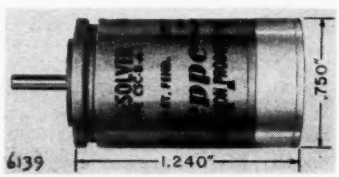


New "Type SDVA" totally-enclosed aircraft motor suitable for actuator, etc., delivers ¼ hp continously at 5700 rpm, operating on 3-phase 400-cps 28 vac; meets applicable military specs; is also available as explosion-proof "Type SEVA."—*U. S. Electrical Motors Inc., Box 2058, Terminal Annex, Los Angeles 54, Calif.*

For more information circle **325** on inquiry card.

SIZE 8 SYNCHROS

New size 8 synchros feature guaranteed 7-minute accuracy; are available in all types; in usual 11.8- or 26-

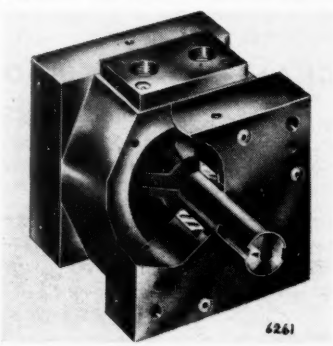


v excitation and also in 115-v 400-cps primary, 90-v secondary transmitters, CTs and receivers.—*Clifton Precision Products Co., Inc., Marple at Broadway, Clifton Hts., Pa.*

For more information circle **326** on inquiry card.

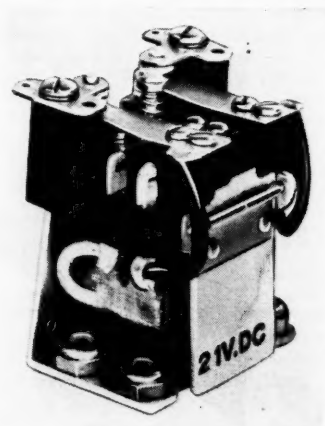
OSCILLATING TORQUE MOTOR

New "Rotomation Motor" is an instant-oscillating torque motor producing up to 280° rotation of a shaft, obviating need of complex linkages, gears, cylinders, cams, clutches, etc.; operates with equal efficiency on air,



ALL-PURPOSE RELAYS

New "Amrecon Model DOS" meets aircraft and industrial needs, can



BORG MICROPOTS

the NEW STANDARD of precision multi-turn potentiometers

BORG 900 SERIES 3-TURN AND 10-TURN MICROPOTS

3-TURN MODELS 931-935 | 10-TURN MODELS 901-903

Standard models of Borg 900 Series Micropots offer such flexibility that they meet special design needs. Borg has created a new standard for high-precision, multi-turn potentiometers.

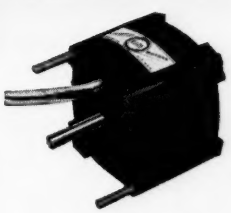
Advantages of the Borg 900 Series include greater accuracy, finer resolution, lower torque, longer life, better performance under severe and excessive vibration, greater adaptability and versatility of applications.

Standard models include: 10-turn precision Micropots in 1 to 5 gang models, 3-turn in 1 to 5 gang models, single or double shafts, servo or bushing mounts on either or both ends. Available to designers and engineers in any quantity.

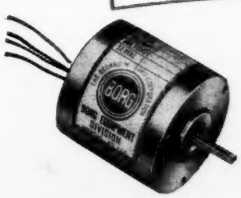
SYNCHRONOUS AND INDUCTION BORG-MOTORS

1000 SERIES 2 POLE AND 4 POLE MODELS
With and Without Gear Trains

These Borg-Motors were designed specifically for instrumentation, control and timing devices. They are recommended for all applications where low torque, constant speed and long life are positive requirements.



For Complete Engineering Data



SERVO-CONTROL
Borg-Motors

Two phase, 115 volt, 400 cps induction type Borg-Motors for servo control applications. Approximate size 1½" diameter x 2" long with a locked rotor torque of 0.82 ounce-inch.

ATTACH TO YOUR LETTERHEAD

BORG EQUIPMENT DIVISION
THE GEORGE W. BORG CORPORATION
JANESVILLE, WISCONSIN

NAME.....

TITLE.....

Please send complete information and engineering data on items checked.

- ☐ Precision Multi-Turn Potentiometers, 900 Series
- ☐ Borg Standard Potentiometers, 1100 Series
- ☐ Precision Multi-Turn Counting Dials
- ☐ Servo Control Motors
- ☐ Frequency Standards
- ☐ Instrument Motors
- ☐ Contract Manufacturing

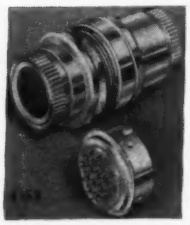
BORG EQUIPMENT DIVISION
THE GEORGE W. BORG CORPORATION
JANESVILLE, WISCONSIN

For more information circle 94 on inquiry card.

handle "power loads usually demanded of much larger and heavier relays."—*Ohmite Mfg. Co.*, 3681 *Howard St., Skokie, Ill.*

For more information circle **330** on inquiry card.

MINIATURE CONNECTORS



New miniature quick-disconnect connectors incorporate 16 industry requirements and meet latest MIL-C-5015 AN "E" specs for instrument rating; feature positive quick-disconnect lock which requires no safety wiring; automatically seal before locking and can be visually inspected for correct assembly and installation.—*The Deutsch Co., 7000 Avalon Blvd., Los Angeles, Calif.*

For more information circle **331** on inquiry card.

MINIATURE COAXIAL CABLES

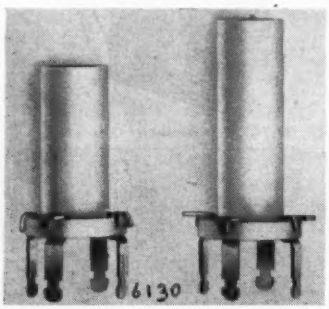
New miniature Teflon-insulated coaxial cables are available in three 50-, 70- and 93-ohm types. Each type can

be obtained with outer covering of Vinyl, Nylon, Kel-F, Teflon or a glass fibre braid. Special low-noise types also available.—*Hitemp Wires, Inc., 26 Windsor Ave., Mineola, N. Y.*

For more information circle **332** on inquiry card.

CERAMIC COIL FORMS

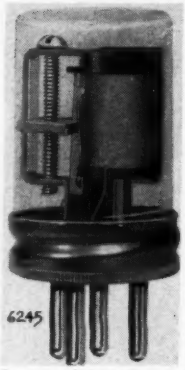
New "SPC-11" and "SPC-12," for printed circuitry, are made of grade L-5 ceramic. Mounted heights 5/8"



and 13/16"; both have ¼" OD and 10/32" threaded powdered iron core and silicone fiberglas collar; are available with 2 to 4 solder lugs.—*Cambridge Thermionic Corp.*, 445 *Concord Ave., Cambridge, Mass.*

For more information circle **333** on inquiry card.

FREQUENCY-CODE RELAY

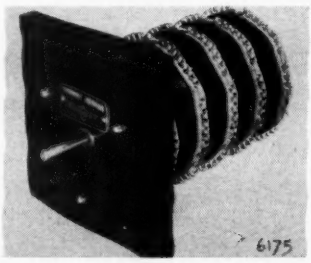


New "Series TR Frequency Relay" has frequency range from 40 to 170 cps (other ranges special). Up to ten such relays can be installed in control panel, each operated by signal to which it is tuned.—*Potter & Brumfield, Princeton, Indiana.*

For more information circle **334** on inquiry card.

LOW-LEVEL SAMPLING SWITCH

New low-level thermocouple or strain-gage high-speed sampling switch has 5 poles with 90 contacts

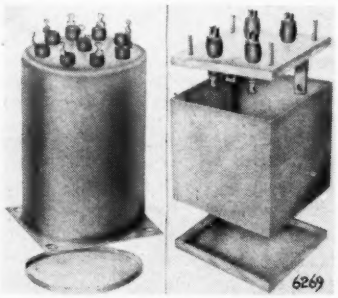


per pole, features dynamic phase adjustment for maximal convenience and and accuracy. Available models include single- or multiple-pole units with stacked, opposed, concentric, raised contact, segmented, and/or printed circuit designs.—*General Devices, Inc., P.O. Box 253, Princeton, N. J.*

For more information circle **335** on inquiry card.

SEALED ENCLOSURES

New hermetically sealed enclosures, along with complete line of hermetic terminals and hermetic headers, offer

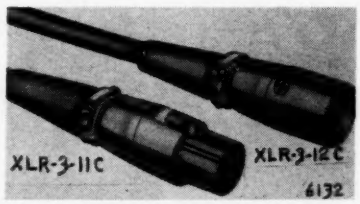


complete package assemblies for hermetic sealing of electronic components. Containers are fabricated to customer specifications.—*Silicone Seals, Inc.*, 3125 *Milwaukee Ave., Chicago* 18, *Ill.*

For more information circle **336** on inquiry card.

AUDIO TYPE CONNECTOR

New "XLR" cord connectors, for aircraft test equipment, instruments, quality microphones, and low-level

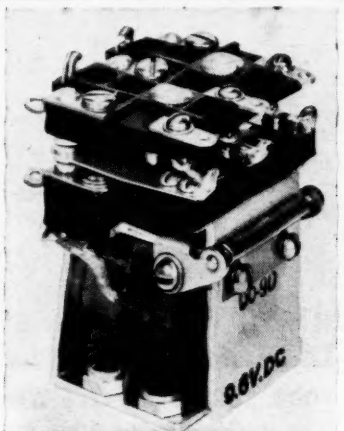


sound application, are shock-proofed to provide quiet connection through use of polychloroprene insulating material which also protects contacts from dust and moisture. Two insert arrangements available: one with three 15-amp contacts for No. 14 wire and one with four 10-amp for No. 16 wire.—*Cannon Electric Co.*, 3209 *Humboldt St., Los Angeles* 31, *Calif.*

For more information circle **337** on inquiry card.

ALL-PURPOSE RELAY

New "Amrecon Model DO" has maximum contact combination of 4p-

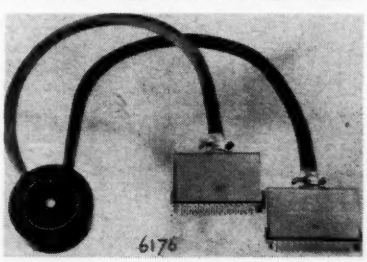


dt; is particularly adaptable to aircraft and vehicles with severe shock and vibration.—*Ohmite Mfg. Co.*, 3682 *Howard St., Skokie, Ill.*

For more information circle **338** on inquiry card.

HIGH-SPEED SWITCHES

New line of high-speed switches of advanced design incorporates an exclusive new semi-model contact plate construction: each contact pin permanently locked into precise alignment for maximal dimensional stabil-



In magnetrons, too

CRUCIBLE PERMANENT MAGNETS

provide maximum energy. . . minimum size

In designing magnetrons for radar systems — or any very high-frequency oscillator application — you can be sure of a *consistently higher* energy product with Crucible alnico magnets. *This means more power from a minimum size magnet!*

Crucible alnico permanent magnets are made to meet practically any size requirement from a fraction of an ounce to several hundred pounds. And they're sand cast, shell molded or investment cast to the exact size, shape, tolerance and finish you need.

Crucible has been one of the largest producers of permanent magnets since the development of alnico alloys. Its unsurpassed magnet experience is backed by over 50 years of fine steelmaking. That's why the best solution to magnet problems starts with a call to Crucible. *Crucible Steel Company of America, Henry W. Oliver Building, Pittsburgh 22, Pa.*

CRUCIBLE first name in special purpose steels

Crucible Steel Company of America

For more information circle **95** on inquiry card.

MEASUREMENTS' MEGACYCLE METER

Gives You Extended Coverage from 100 Kc to 940,000 Kc

PRECISION GRID-DIP METERS

MODEL 59
Power Supply $75.00

MODEL 59-LF OSCILLATOR UNIT

Frequency Range: 100 Kc to 4.5 Mc. Price - Oscillator Unit (Head) only $98.50 with Power Supply $168.00

MODEL 59 OSCILLATOR UNIT

Frequency Range: 2.2 Mc to 420 Mc. Price - Oscillator Unit (Head) only $98.50 with Power Supply $168.00

MODEL 59-UHF OSCILLATOR UNIT

Frequency Range: 420 Mc to 940 Mc. Price - Oscillator Unit (Head) only $123.00 with Power Supply $198.00

Measurements' Megacycle Meter is now available in a choice of three oscillator heads providing frequency range coverage from 100 Kc to 940,000 Kc. Thus, the utility of this versatile instrument has been extended, making it, more than ever, indispensable to anyone engaged in electronic work; engineer, serviceman, amateur or experimenter.

Laboratory Standards

MEASUREMENTS CORPORATION
BOONTON • NEW JERSEY

For more information circle **96** on inquiry card.

NEW INSTRUMENTS

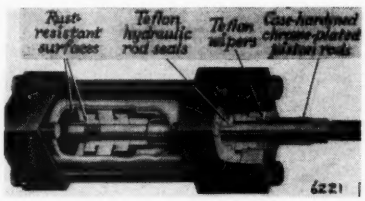
ity. Available models include single- or multiple-pole, stacked, concentric, opposed, raised contact, segmented, or printed circuit designs.—*General Devices, Inc., P.O. Box 253, Princeton, N. J.*

For more information circle **339** on inquiry card.

MECHANICAL COMPONENTS

POWER CYLINDERS

New complete line of air and hydraulic cylinders features improvements and refinements designed to

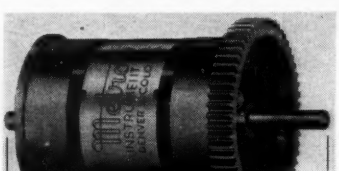


provide longer cylinder life, improved performance and wider use at no extra cost. Teflon wipers and seals withstand temperatures from −100° F to 500°F. Black oxide finish provides rust protection in air cylinder operation and on all cylinders during shipping and installation.—*Miller Fluid Power Co., 2040 N. Hawthorne Ave., Melrose Park, Ill.*

For more information circle **340** on inquiry card.

MINIATURE DIFFERENTIAL

New miniature differentials combine two rotating inputs to give speed sums or differences and angular sums

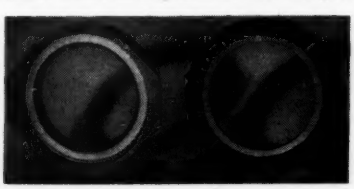


or differences, are also suitable for controlling relative speeds, shifting phase angles between rotating shafts, and quickly reversing and changing speeds without disconnecting power source. Thirty-four different ratios from 1:1 to 27:1.—*Metron Instrument Co., 432 Lincoln St., Denver 3, Colo.*

For more information circle **341** on inquiry card.

ALUMINUM COMPONENTS

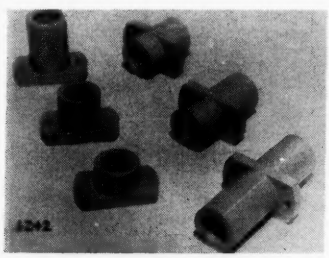
New component is a combination gear and bearing, made of aluminum. Inner race has gear as an integral part, utilizing both race faces to make dial and indicator for an airborne instrument. Outer race is flanged to provide mounting positions. Other aluminum components are available in various sizes, for functions such as oscillating motion, etc.—*Halax Corp., 17470 Shelbourne Way, Los Gatos, Calif.*



For more information circle **342** on inquiry card.

BEARING ADAPTERS

New "Type AA Precision Bearing Adapters," immediately available from stock, are for use where vertical

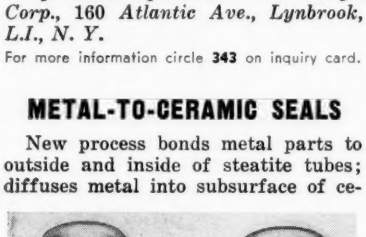


or horizontal complete shaft assemblies are required; can be used as floating adapters to minimize backlash. Dowel holes are provided for spot drilling through after setting for permanent positions.—*PIC Design Corp., 160 Atlantic Ave., Lynbrook, L.I., N. Y.*

For more information circle **343** on inquiry card.

METAL-TO-CERAMIC SEALS

New process bonds metal parts to outside and inside of steatite tubes; diffuses metal into subsurface of ce-



ramic, so that bond is as strong as ceramic body itself. Another advantage is that an inside or recessed metal-to-ceramic seal can increase leakage path by as much as twice normal without increasing over-all length of seal, or, with a given leakage path, reduce over-all length by as much as one-half.—*Victoreen Instrument Co., 5806 Hough Ave., Cleveland 3, Ohio.*

For more information circle **344** on inquiry card.

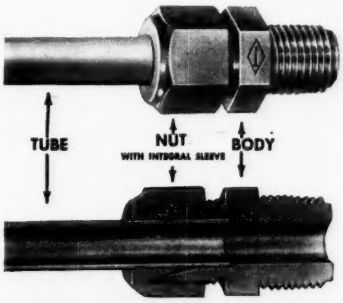
POTTING COMPOUND

New "PR-1401-Q" high-tempera- and potting compound for sealing and potting electrical connectors features room-temperature cure to a firm, resilient, moisture and vibration-resistant rubber seal. Prolonged exposure to 257°F. does not materially reduce physical or electrical properties.—*Products Research Co., 3126 Los Feliz Blvd., Los Angeles 39, Calif.*

For more information circle **345** on inquiry card.

NYLON FITTINGS

New "Nylo-Seal" tube fittings, molded from DuPont "Zytel" (Nylon), can be used with either plastic



or metal tubing; are impervious to most acids and alkalies; withstand temperatures from —70°F to 250°F. Recommended pressures 150 to 500 psi, depending on temperature.—*Imperial Brass Mfg. Co., 1200 W. Harrison St., Chicago 7, Ill.*

For more information circle **346** on inquiry card.

PROTECTIVE COATING FOR GRAPHIC CIRCUITRY

New "Photofinish #4" non-oxidizing non-corrosive film protects and prolongs shelf life of etched circuit boards that are inventoried prior to assembly and dip soldering. It is applied after etching the graphic circuitry; is hardly perceivable; vaporizes upon contact with hot solder, leaving no disagreeable residue or contaminating solder pot when dip soldering. —*Photocircuits Corp., Glen Cove, N.Y.*

For more information circle **347** on inquiry card.

CERAMIC TUBING

New "AlSiMag 555" crushable tubing for insulating enclosed heating elements is completely uniform, is an excellent electrical insulator and a

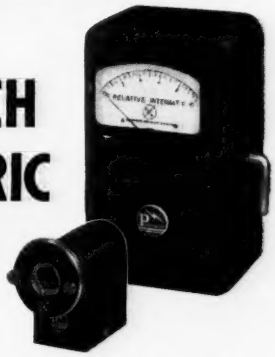
WITHOUT EQUAL

in fast, flexible, accurate control of

HIGH TEMPERATURES

New

PHOTOSWITCH PHOTOELECTRIC PYROMETER



The Photoswitch Photoelectric Pyrometer is a *precision instrument* with all the speed, flexibility, and ruggedness of a *production tool.*

■ **AT A DISTANCE,** the hot object is scanned by a special phototube whose electrical output is proportional to the temperature. There are no delicate connecting wires, no junctions to burn out.

■ **CONTINUOUS TEMPERATURE INDICATION** is shown on a meter, with no perceptible lag. Total range of the instrument is from 1000° to 5000°F. Operating ranges can be selected by varying the calibrated opening of the scanner lens assembly.

■ **CONSTANT ACCURACY** results from a *selective* response to infrared radiation that substantially reduces interference caused by oxides or scale on the hot object, or vapor and smoke in the scanner's field of view.

■ **AUTOMATIC CONTROL** of temperature is provided through a heavy-duty relay in the control unit, actuated when the temperature changes by as little as 5° from any pre-set point. Through the relay, the primary heat supply — or any desired process step — can be governed.

■ **RUGGED, TROUBLE-FREE SERVICE** has been proved in many applications. Typical are induction heating, metal forming, flame hardening, continuous brazing.

Photoswitch DIVISION

ELECTRONICS CORPORATION OF AMERICA

Dept. 32-2, 77 Broadway • Cambridge 42, Massachusetts

WRITE FOR BULLETIN PT 556

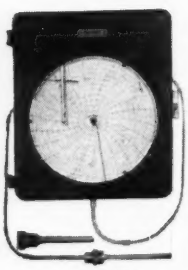
For more information circle **97** on inquiry card.

4½" DIAL THERMOMETERS

Made in 3 types to suit any requirements. Rigid stem, wall or flush mounted, 11 inches of scale reading. Interchangeable with standard industrial separable sockets. Stem can be placed at any angle and case can be rotated to any readable position.

PALMER
MERCURY ACTUATED
Temperature Indicating Instruments

RECORDING THERMOMETERS



Twelve inch die-cast aluminum case with black or white wrinkle or satin finish. Single or multiple pen construction. Electric or spring wound clock, 24 hour or 7 Day Revolution. Flexible Armor and bulb of stainless steel. Ranges —40 +950°F or Equivalent in °C.

INDUSTRIAL THERMOMETERS

Red-Reading Mercury —Extruded brass case — chrome finish. Ranges —40 + 950°F or Equivalent in °C.

RED-READING MERCURY LABORATORY THERMOMETERS

Thoroughly annealed for permanent accuracy. Complete line A.S.T.M. and fractional division types.

Write For Catalog Information

PALMER
THERMOMETERS, INC.
Cincinnati 12, Ohio • MElrose 1500

For more information circle **98** on inquiry card.

NEW INSTRUMENTS

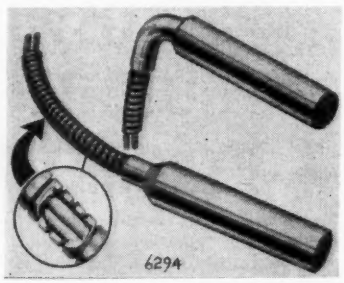
superior heat conductor. Elements are easily inserted into holes in "AlSi-Mag 555" tube which, in turn, slips into outer metal sheath of heating element and is then swaged. Swaging crushes ceramic and forms a compact layer of small particles surrounding and holding element.—*American Lava Corp., Cherokee Blvd. & Mfgrs. Rd., Chattanooga 5, Tenn.*

For more information circle **348** on inquiry card.

MISCELLANEOUS

CARTRIDGE HEATERS

New models of "Chromalox" electric cartridge heater have lead wires with complete moisture and vapor

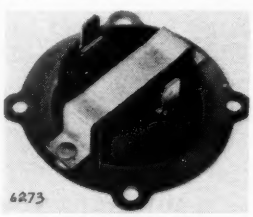


protection: a new flexible rust-proof brass conduit covering whose locking spirals are sealed against moisture leakages.—*Edwin L. Wiegand Co., 7500 Thomas Blvd., Pittsburgh 8, Pa.*

For more information circle **349** on inquiry card.

SNAP-ACTION THERMOSTAT

New "Stemco Type D" snap-action bimetal disc thermostat for clothes dryers, furnace ducts and other



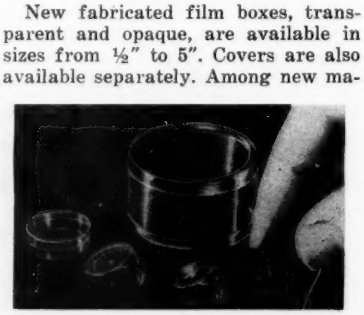
warm-air applications is UL-approved for operation to 300°F; is rated at 25 amps at 120-240 vac non-inductive; ½ hp at 120-240 vac; and 345 va for pilot duty.—*Stevens Mfg. Co., Inc., P. O. Annex 1007, Mansfield, Ohio.*

For more information circle **350** on inquiry card.

PACKAGING CONTAINERS

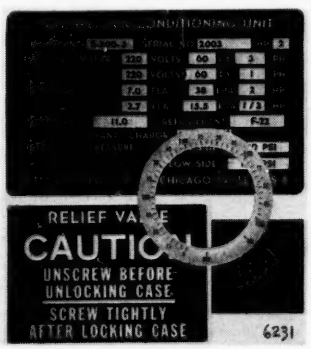
New fabricated film boxes, transparent and opaque, are available in sizes from ½" to 5". Covers are also available separately. Among new materials used is "Mylar," with unusual heat, chemical and electrical resistance. Vials packaged in a "Mylar" box can be heat sterilized after loading.—*Falge Engineering Corp, 214 N. Main St., Hudson, Ohio.*

For more information circle **351** on inquiry card



NAMEPLATES

New "Thinplates" are color anodized aluminum foil nameplates which can be bonded to any surface.

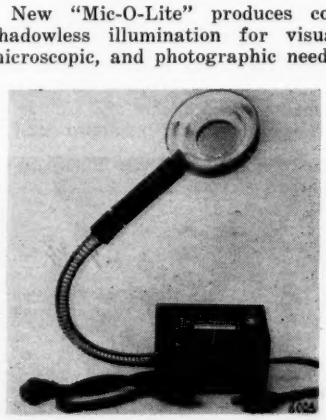


Material is adhesive-backed aluminum foil, 0.003" or 0.005" thick, which meets all pertinent government specs. "Thinplates" have permanence of anodized aluminum; will not tarnish, oxidize, chip, peel or crack; withstand 250 hours in "Weatherometer"; 100% humidity at 95°F; clearly legible after 17,000 cycles on Taber "Abraser."—*Park Nameplate Co. Inc., 61-07 Thirty-second Avenue, Woodside 77, N. Y.*

For more information circle **352** on inquiry card.

AROUND-LENS LIGHT

New "Mic-O-Lite" produces cool shadowless illumination for visual, microscopic, and photographic needs;



2½" source surrounds specimen with light; available interchangeable lamps include blacklight, u-v germicidal, etc.—*Aristo Grid Lamp Products, Inc.*, 106-23 *Metropolitan Ave., Forest Hills, N. Y.*

For more information circle **353** on inquiry card.

HYDRAULIC SYMBOLS TEMPLATE

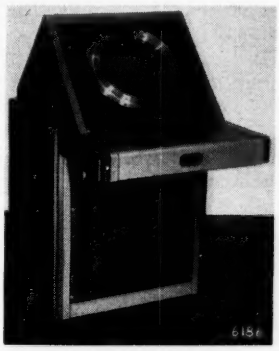
New "No. 46" hydraulic symbols template has cut-outs that depict J. I. C. Standard symbols for design-

ing hydraulic circuits; is made of 0.030" matte finish plastic, with all cut-outs precision milled. Size 7" X *4½".—*Rapidesign, Inc., Box* 592, *Glendale, Calif.*

For more information circle **354** on inquiry card.

AUDIO-CIRCUIT RADAR

New "Rafax" system permits transmission of PPI type radar information over audio circuits such as tele-



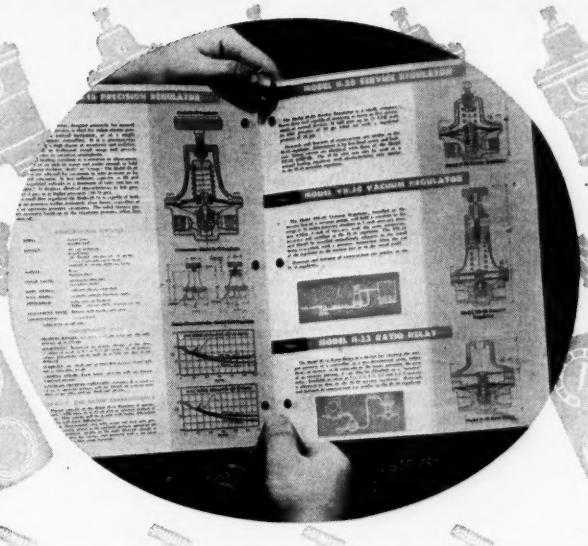
phone lines or radio links; consists of (1) Encoder that receives radar video and antenna rotation information and, after bandwidth compression, places this information on two carriers; (2) Decoder that separates the two subcarriers and extracts modulation information; (3) Indicator (shown) which accepts either decoder output or normal radar signals. Since Rafax signals are of audio bandwidth, they can be recorded on standard magnetic tape.—*Haller, Raymond & Brown Inc., State College, Pa.*

For more information circle **355** on inquiry card.

CARRIER TELEPHONE

New improved model of "Trolleyphone" system, for industrial applications such as between crane cab and

ONLY CONOFLOW OFFERS A COMPLETE SELECTION of PNEUMATIC REGULATORS



- √ MODEL H-10 PRECISION REGULATOR
- √ MODEL PH-10 REMOTE CONTROL PANEL
- √ MODEL FH-20 FILTER-REGULATOR
- √ MODEL F-1 AIR FILTER
- √ MODEL H-20 SERVICE REGULATOR
- √ MODEL VH-20 VACUUM REGULATOR
- √ MODEL H-22 RATIO RELAY
- √ MODEL DH-21 PURGE ASSEMBLIES

Only Conoflow stocks *a complete line* of precision-made, low cost, pneumatic regulators which meet all the rigid requirements of the instrument industry.

Conoflow regulators are used to maintain a filtered and regulated supply to pneumatic instruments . . . on test stands . . . for a variety of applications on packaging machines . . . on remote manual control panels . . . for purging lines on differential manometers . . . in bleed systems . . . for manual to automatic by-pass service, etc., etc.

Write today for Bulletin H-2 illustrating and describing the Conoflow Series "H" regulator line. It's chock-full of cross section and dimension drawings — performance characteristics and applications. It will be mailed to you promptly, without obligation.

CC601

Conoflow Controls

CONOFLOW CORPORATION

FOREMOST MANUFACTURER OF FINAL CONTROL ELEMENTS

2100 Arch Street, Philadelphia 3, Pa.

SALES-ENGINEERING REPRESENTATIVES IN PRINCIPAL CITIES

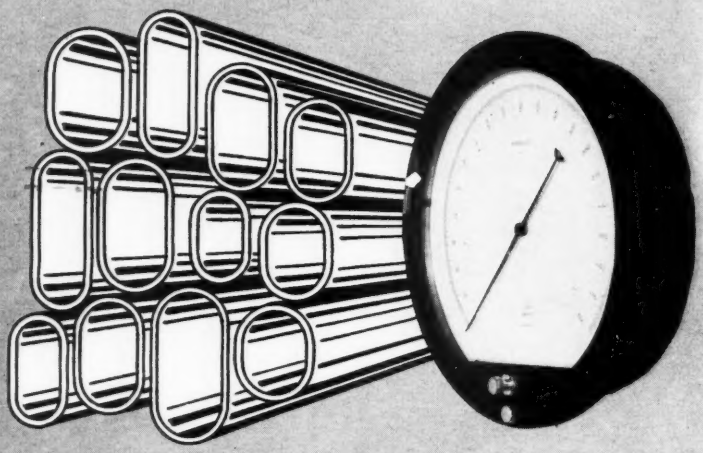
Subsidiary of Walworth Company

For more information circle **99** on inquiry card.

HEISE GAUGES

Designed for Dependability

Does your high pressure gauge application require a scientifically designed Bourdon Tube?



Where highly accurate results are required design considerations such as the depth — width ratio of the Bourdon Tube section are of paramount importance.

Extreme fiber stress resulting from improper design of the tube may render an apparently good instrument completely undependable.

At the Heise Laboratories, mathematical solutions for determining the size and shape of Bourdon Tubes for specific use are augmented by years of research and tests on various types of tubes to assure correct stress distribution.

Heise Bourdon Tubes are heat treated by scientific methods to guarantee that each tube will be metallurgically sound for its application. The precision heat treatment of thin walled tubing without distortion has been made possible by equipment and technique developed by Heise Laboratories.

Catalog on Request

Pressure Ranges 15 to 20,000 P.S.I. Dial Sizes 8½"—12"—16"

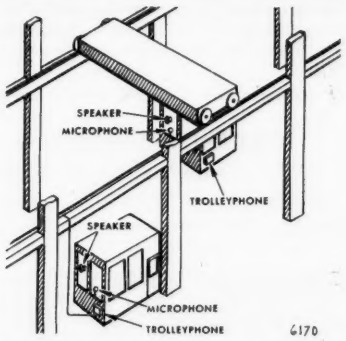
Prices from $151.60. **DELIVERY WITHIN 30 DAYS.**

HEISE BOURDON TUBE COMPANY, INC.

BROOK ROAD, NEWTOWN, CONNECTICUT, U.S.A.

For more information circle **100** on inquiry card.

NEW INSTRUMENTS



floor station in steel mills, provides two-way conversation between fixed stations and operators of moving equipment, or between operators of two or more units of moving machinery, without wiring of a telephone system but with all of advantages of latter.—*Femco, Inc., Irwin, Pa.*

For more information circle **356** on inquiry card.

LOW-COST INTERCOM

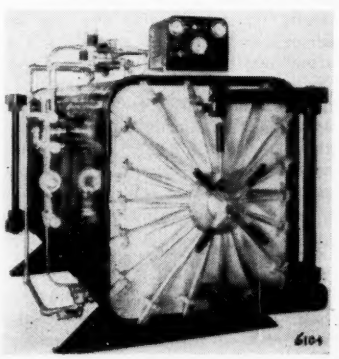
New "Select-A-Call" push button telephone systems for small plants, etc., where cost is factor, have 2 to 12

stations; feature selective signalling, common talking, lamp indication when line is in use. Operable up to 5 miles. Optional equipment for paging over PA system, code calling, Telecom speaker phone, monitoring given areas, etc.—*Telecom, Inc.*, 1019 *Admiral Blvd., Kansas City* 6, *Mo.*

For more information circle **357** on inquiry card.

AUTOMATIC STERILIZER

New electrically-operated sterilizer is fully automatic. After initial starting no attention is required; when



entire cycle is completed an audible signal is sounded. Recessed or floor-standing units, either single- or double-door, are available for three types of discharge: slow for liquids, fast for utensils, fast for dressings.—*Aetna Scientific Co., Spring & Second Sts., Everett, Mass.*

For more information circle **358** on inquiry card.

PROTECTIVELY PACKAGED CONTACTS

New packaging program to protect electrical contacts in shipment and in storage involves use of polyethylene plastic containers completely free of contaminating or corrosive effects on contact materials which are a problem with many types of paper and cardboard containers.—*P. R. Mallory & Co., Inc., 3029 E. Washington St., Indianapolis 6, Ind.*

For more information circle **359** on inquiry card.

FIRE DETECTION SYSTEMS

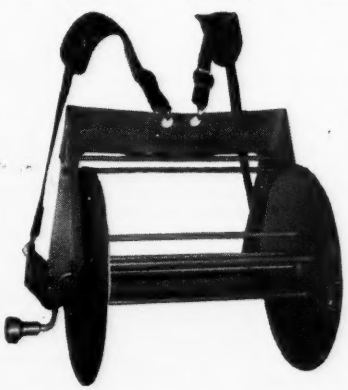
New "PN-02-AD Series" systems are both UL and FML listed and are recognized by Rating Bureaus for

substantial fire insurance rate reductions when used either for automatic fire detection or sprinkler supervision.—*Notifier Mfg. Co., 239 South 11th St., Lincoln 8, Nebraska.*

For more information circle **360** on inquiry card.

PORTABLE REELS

New light-weight portable aluminum reels can be used for stringing line, laying small geophysical cables,



Winter shipment of perishables in refrigerator cars requires a dependable heating device to eliminate spoilage. The Preco Automatic Refrigerator Car Heater is now used by the thousands to insure protection of such perishables as fruits and vegetables when shipped during freezing weather.

This Preco heater burns methanol which eliminates poisonous fumes and is explosion proof. It burns on full flame for 50 hours with one tank of methanol and delivers a heat output of 6000 BTU's per hour.

How It Works—A central tube contains a spun-glass wick which draws up the methanol from the tank and is lighted at the top surface. In operation, the pilot light burns constantly, either on pilot or on full flame. A coil of Chace Thermostatic Bimetal (B) regulates the degree of combustion by controlling the amount of oxygen admitted to the wick, according to the temperature in the car. The bimetal coil, with one end fixed to the housing and the other to the shaft (C), reacts to temperature change by rotating the shaft with lever (D) attached, lifting or lowering the snuffer arm and plate (A) over the flame. Thus, the amount of oxygen available for combustion is varied to produce a greater or lesser degree of heat.

Chace Thermostatic Bimetal is available in 29 types, in strip, coils or in complete elements made to your specifications. Write now for our free 36-page booklet, "Successful Applications of Thermostatic Bimetal," containing valuable information for designers of thermally responsive devices.

W. M. CHACE CO.
Thermostatic Bimetal
1609 BEARD AVE., DETROIT 9, MICH.

For more information circle **101** on inquiry card.

New!

IDEAL SURVEY METER FOR RADIATION SAFETY

- **Compact, convenient, accurate**
- **Operates on a single flashlight cell**
- **Weighs only 2 pounds**
- **Beta or gamma by twist of a knob**
- **Two ranges: 0-25 mr/hr, 0-1 r/hr**
- **Accessories to multiply or divide both ranges by 10**

Curtiss-Wright

RADIAMETER

The Curtiss-Wright Radiameter is a radiation survey meter designed especially for health physics and industrial hygiene applications. Using a unique inverted triode circuit, it performs functions usually requiring two instruments. The lower scale provides high sensitivity for decontamination monitoring. The high scale measures stronger radiation fields usually requiring an ionization chamber type instrument.

Where other radiation survey meters require several expensive and hard-to-find batteries, the Radiameter is powered by a single inexpensive flashlight cell. It is easy to handle and slips readily into a suit coat pocket.

Having the appearance of a light meter or camera, it attracts minimum attention from plant personnel during safety checks. The one-piece cast aluminum case is light in weight, but extremely rugged and waterproof. The Geiger tube or battery may be changed in seconds and without tools. Controls are simple, even for non-technical personnel, and the meter is easy to read.

Accuracy is ±10% of full scale on both scales for energies from 50 to 1,200 kev. The Radiameter is useful for monitoring energies as low as 15 kev. In the presence of radiation of high intensity, the instrument does not overload but continues to read off-scale. It can be zeroed even in a strong field. Its fast response permits monitoring x-ray installations turned on only momentarily. Battery life is long—approximately 140 hours.

Available accessories include a probe to multiply sensitivity by 10, a tube to divide sensitivity by 10, an alpha tube, a radium calibration source, a push-button on-off switch, and an attractive leather carrying case. Write for details.

Component and Instrument Sales Department

ELECTRONICS DIVISION
CURTISS-WRIGHT
CORPORATION • CARLSTADT, N. J.

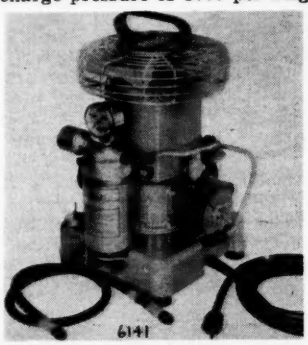
For more information circle **102** on inquiry card.

etc. Seven models accommodate from 1,500 to 7,500 ft of level-wound ⅛" cable.—*Southwestern Industrial Electronics Co.*, 2831 *Post Oak Rd., Houston* 19, *Texas.*

For more information circle **361** on inquiry card.

H-P AIR COMPRESSOR

New "Model 130R1500" with capacity of 1.75 cfm of free air and rated discharge pressure of 3000 psi weighs

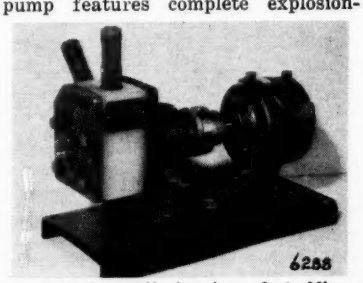


38 lbs. Assembly includes compressor, oil filter and moisture separator, self-resealing relief valve, 0-4000 psi pressure gage, and an integral 110-220-v 60 cps motor especially designed for new compressor. Relatively low discharge rate helps insure that compressed air will be free of contamination with oil and moisture.—*The Cornelius Co.*, 550 39*th Ave. N.E., Minneapolis* 21, *Minn.*

For more information circle **362** on inquiry card.

PORTABLE AIR-MOTOR PUMP

New portable air-motor-driven self-priming chemical and slurry pump features complete explosion-



proof design; elimination of stuffing-box or mechanical-seal leakage; wide range of variable-speed operations. Can be furnished with reversible feature for operation in either direction. Capacities to 20 gpm; pressure to 50 psi.—*Vanton Pump & Equipment Corp.*, 201 *Sweetland Ave., Hillside, N. J.*

For more information circle **363** on inquiry card.

HIGH-VACUUM PUMPS

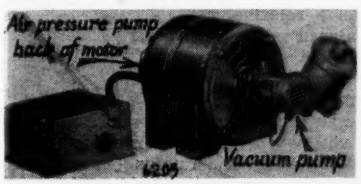
New "Model 900" high-vacuum pumps have a guaranteed vacuum of 0.01 mm Hg, capacity of 24 liters of free air per minute, pumping speed 0.26 liter/second at 0.1 mm (said to

be "the best of any comparable capacity pump"). Also included in new line are vacuum-pressure and water-cooled models.—*George F. Nelson Vacuum Pump Co.*, 2133 *Fourth St., Berkeley* 10, *Calif.*

For more information circle **364** on inquiry card.

COMBINATION PRESSURE AND VACUUM PUMP

New "Model RG-15180" has pressure pump with 400 cipm capacity at 30 psi gage discharge pressure; positive starting and pumping in temperature range of 55°C (131°F) to —65°C (—67°F). Vacuum pump can be operated simultaneously with pressure pump or separately; provides a vacuum of 0.20" Hg abs at pumping speed of 400 cu in per minute; can operate at reduced capacity to low temperature of —55°C (—67°F). Motor is 110 vac, ¼ hp, operates at 3450 rpm, capacitor start.—*Lear-Romec Div., Lear, Inc., Elyria, Ohio.*



For more information circle **365** on inquiry card.

PRESSURE REGULATORS

New "Governaire" controls, for pneumatic loading and gaging applications, feature minimum pressure offset in passing steady state condition. Eight types now in production include pressure regulators, volume boosters and reversing relays. Specifications of a typical regulator, "Series 4000," include five ranges from 10 to 250 psi; high-capacity ⅝" diameter supply and exhaust seats; three sizes (⅜", ½" and ¾" NPT with two ¼" gage taps).—*Governaire Div., Bellofram Corp., Burlington, Mass.*

For more information circle **366** on inquiry card.

CENTRIFUGAL BLOWER

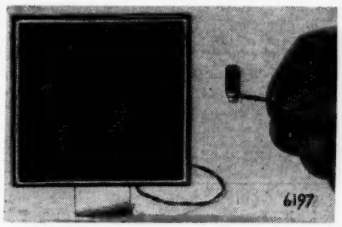
New "Model R Type 3501" blower, for applications requiring a high pressure-to-volume cooling performance,

weighs 3 lbs; is particularly suitable for operation at high shaftspeeds obtainable with 400-cps power supplies; is capable of moving 25 cfm at 7.5" wc at 11,000 rpm.—*Rotron Mfg. Co., Schoonmaker Lane, Woodstock, N. Y.*

For more information circle **367** on inquiry card.

SUN BATTERY CELLS

New series of selenium sun battery cells features low cost and high self-generated output which make them



ideal components for control applications, transistor power supplies, photometric equipment, as well as experimental uses. Wide range of sizes from 0.1 to 15 milliwatts power output in direct sunlight.—*International Rectifier Corp.*, 1521 *E. Grand Ave., El Segundo, Calif.*

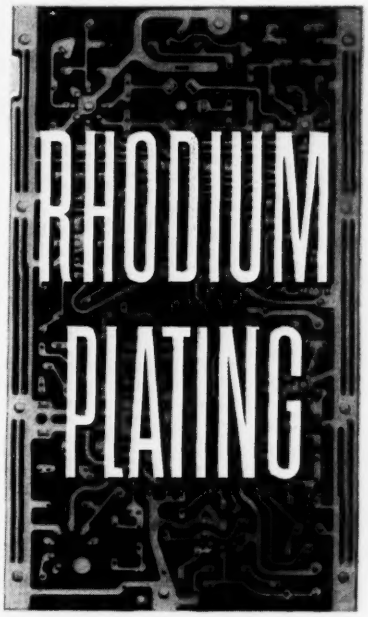
For more information circle **368** on inquiry card.

"FADE-OUT-GRID" DRAWING AND TRACING PAPER

New drawing and tracing paper with "disappearing" grid lines is available in 20-, 50-, and 100-yd rolls, widths from 24" to 42"; is printed with light-blue cross-section rulings which completely disappear on direct print reproductions and blueprints. Using printed grid as a guide, scale drawings and freehand lettering are quickly made without penciled guide lines or mechanical scaling aids. Pencil and ink lines can be erased repeatedly without "ghosting." Paper is made in 16-lb and 20-lb stock with grid lines printed 8 x 8 or 10 x 10 to the inch, inch lines heavy. (Also available as before in sheets up to 42" wide and in 8½ x 11" pads.)—*Clearprint Paper Co.*, 1482 67*th St., Emeryville, Calif.*

For more information circle **369** on inquiry card.

PROTECT
PRINTED
CIRCUITS
AGAINST
CORROSION...



Rhodium over nickel, or over silver in printed circuits—is only one of the many invaluable applications of Rhodium in electrical and electronic products. It improves performance wherever a low resistance, oxide-free contact is desired. Rhodium plate assures low noise level for moving contacts, low and stable contact resistance . . . and amazingly long wear.

For complete details send for free booklet on "Rhodium Plating" and its advantages.

BAKER & COMPANY, INC. PRECIOUS METALS

113 ASTOR STREET, NEWARK 5, N. J.
NEW YORK • CHICAGO
SAN FRANCISCO • LOS ANGELES

ENGELHARD INDUSTRIES

For more information circle **103** on inquiry card.

INSTRUMENTS and AUTOMATION Briefs

For this literature circle number on inquiry card.

Nuclear Research Reactors

Three principle types of G-E nuclear reactors are available to fulfill the practical thermalpower needs of nuclear research: (1) Nuclear Test Reactor (GE-NTR). (2) Water-Boiler Reactor (GE-WBR). (3) Swimming Pool Reactor (GE-SPR).

The Nuclear Test Reactor is a thermal, heterogeneous, oil or water-cooled graphite-moderated research reactor. Prototypes of this equipment have been in operation for two years at the Knolls Atomic Power Laboratory, operated by G.E. for the Atomic Energy Commission and at the AEC Savannah River Installation . . .

Specifications

Power Level	GE-NTR 30 kw	GE-WBR 50 kw	GE-SPR 1000 kw
Fuel	Enriched U-235	U-235 Uranyl sulfate water solution	Enriched U-235
Moderator	Graphite	Water and Graphite	Water
Size	5 ft square		20 ft square

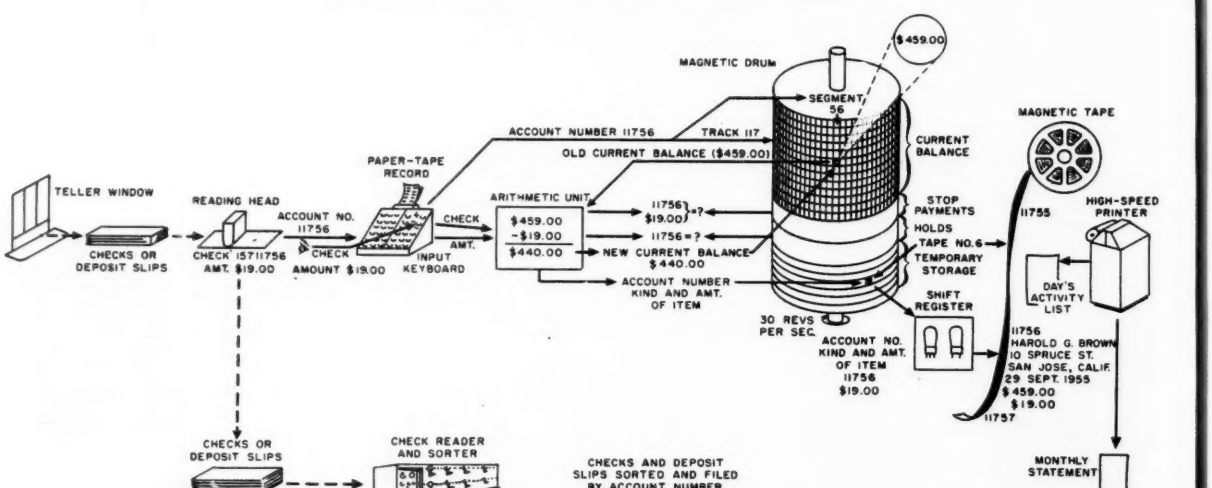
The General Electric Water-Boiler Reactor is a thermal homogeneous, water-cooled, water and graphite-moderated reactor. Based on the Los Alamos homogeneous reactor it operates at moderate power levels producing relatively high neutron fluxes at much less cost than large heterogeneous reactors and with a minimum of fissionable material . . .

The General Electric Swimming Pool Reactor is a thermal, heterogeneous reactor immersed in a 20-foot pool of water which acts as a relatively inexpensive moderator, coolant, and shield. Based on the Oak Ridge swimming pool reactor, the GE-SPR is a versatile research reactor adaptable to high power operation . . .

In addition to nuclear reactor systems, General Electric will also design and build the reactor system components. For instance, G. E. will provide: Instrumentation . . . Control Systems . . . Electromagnetic Pumps (have no moving parts and can handle radioactive fluids safely) . . . (*From 8-page Bulletin GEA-6326, General Electric Co., Schenectady, N. Y.*)

For this literature circle **401** on inquiry card.

Erma—Electronic Bookkeeper



A "revolutionary" electromechanical accounting machine can handle all bookkeeping functions for 32,000 checking accounts. Future production models will serve 50,000 accounts. ERMA (Electronic Recording Machine, Accounting), developed for the Bank of America credits individual accounts with deposits, debits withdrawals, remembers details of all transactions, maintains correct balances, accepts stop-payments and hold orders, prevents overdrawing of accounts, and sorts checks. (*From "Research for Industry", News Bulletin Vol. 7, No. 9, October 1955. Stanford Research Institute, Menlo Park, Calif.*)

For this literature circle **402** on inquiry card.

Photo courtesy American Gyro Corporation

How to keep a missile on target

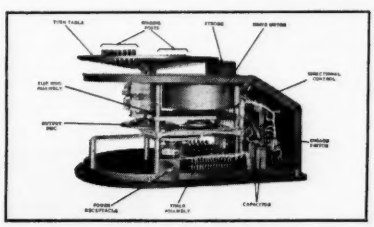
Genisco Rate-of-Turn Tables provide a fast, precise means of calibrating and evaluating rate gyros

It is imperative that components used in missile guidance systems perform to precise specifications. The Genisco Rate-of-Turn Table is a precision test machine used to calibrate and evaluate rate gyroscopes, vital components in missile guidance systems. Almost all major gyro manufacturers are now using these precision turntables in their test programs.

SMOOTH, CONSTANT ROTATION—Rotation of the table is infinitely-variable from 0.01° to 1200° per second. Constancy of angular velocity is within 0.1%, including drift and wow errors. This accuracy is due in large measure to a unique 400-cycle, 180 r.p.m. synchronous motor and a ball-disc integrator drive system. Absence of gears, belts, pulleys, etc., eliminates rotational irregularities inherent in gear-driven machines.

SPECIALLY SUITED FOR TESTING LARGE QUANTITIES—Operation of the machine is extremely simple. Precise rates can be set quickly and easily, using only a single handwheel, and without "hunting" or having to read complicated scales. These features enable inexperienced personnel to become proficient in the operation of the machine after a few minutes' instruction.

The machine is unusually rugged and operates for long periods with a minimum amount of maintenance.



Interior view of the Genisco Rate-of-Turn Table, Model C181, shows the neat, compact design. More than 100 of these precision machines are now in use.

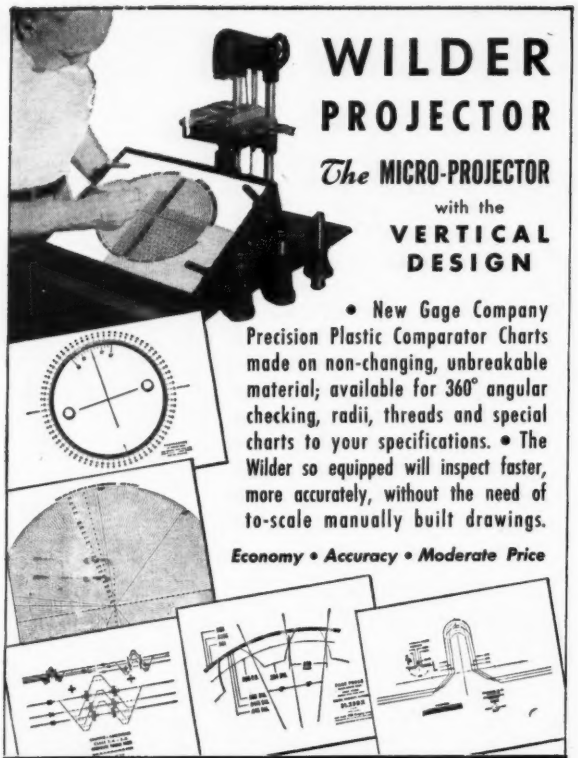
For more information circle **104** on inquiry card.

Several instruments (total weight 100 lbs.) can be tested simultaneously without affecting accuracy.

LOW ELECTRICAL NOISE LEVEL—Sixteen slip rings in the machine provide electrical connections from the rotating objects to the control panel. Copper graphite brushes and coin silver slip rings reduce electrical and AC pickup noise below two millivolts per slip ring.

If your problem is development of a single laboratory prototype or production-line calibration and evaluation of rate gyros, write for complete technical data. Address your inquiry to: Contracts Manager, Genisco, Incorporated, 2233 Federal Avenue, Los Angeles 64, Calif.

Genisco
INCORPORATED



WILDER PROJECTOR

The MICRO-PROJECTOR with the VERTICAL DESIGN

• New Gage Company Precision Plastic Comparator Charts made on non-changing, unbreakable material; available for 360° angular checking, radii, threads and special charts to your specifications. • The Wilder so equipped will inspect faster, more accurately, without the need of to-scale manually built drawings.

Economy • Accuracy • Moderate Price

Geo. SCHERR OPTICAL TOOLS, Inc.

200-MG LAFAYETTE ST. • NEW YORK 12, N. Y.

For more information circle **105** on inquiry card.

JEWELS *for* INDUSTRY. . .

By MOSER JEWEL COMPANY, pioneer industrial jewel manufacturer for over 50 years.

- HIGHLY POLISHED STEEL PIVOTS AND STAFFS
- HARD ALLOY WELDED TIPS
- NON-MAGNETIC STAFFS
- DIAMOND POINTS

FOR INFORMATION ON HOW WE MAY FILL YOUR REQUIREMENTS

Write to . . .

MOSER JEWEL COMPANY

P.O. Box 150 • Perth Amboy, N. J.

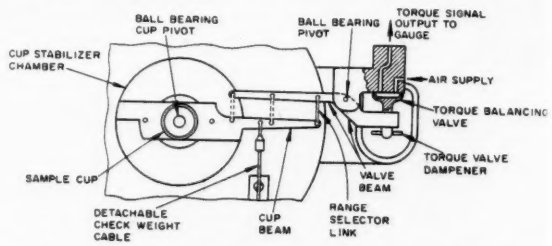
"Manufacturers of all types of Industrial Jewels"

For more information circle **106** on inquiry card.

BRIEFS—CONTINUED

High Shear Viscometers

The Hagan Viscometer, developed especially for use in the paper industry, offers a new approach to the design



of rotational viscometers capable of producing high rates of shear. It consists of four principal components:

1. A variable speed transmission driven by a constant speed motor.
2. A stationary sample cup and driven bob with convenient knob for lifting bob.
3. A pneumatic torque measuring device.
4. A recording Hagan Ring Balance Gauge for recording the torque due to the viscous drag of the sample and the corresponding rate of shear.

The basic principle of the torque measuring device involves measuring a force by automatically supplying a counter balancing force established by a pneumatic pressure imposed upon a known area. The measurement of this pneumatic pressure then becomes an accurate measure of the torque developed by viscous drag . . . (*From* 8-*page Bulletin MSP*-125, *Hagan Corp., Pittsburgh* 30, *Pa.*)

For this literature circle **403** on inquiry card.

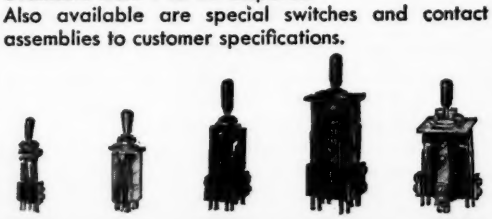
Type MCM Lever Switch

MCM

All lever combinations available. Four contact quadrants. Variety of circuits permitted. Ball-bearing lever action is smooth and positive. 5 amp. contacts are mounted on an easily removed contact block. Single-hole mounting.

Write for Bulletin CL-100

All General Control switches feature riveted coin silver or palladium alloy contacts and are individually adjusted and inspected. Switch types are available from 1 to 10 amperes.
Also available are special switches and contact assemblies to customer specifications.



MCS MCT MCM MCL MFM

FOOT LEVER, PUSH BUTTON and LIMIT SWITCHES
ELECTRONIC and SYNCHRONOUS-MOTOR TIMERS
CUSTOM CONTROL PANELS

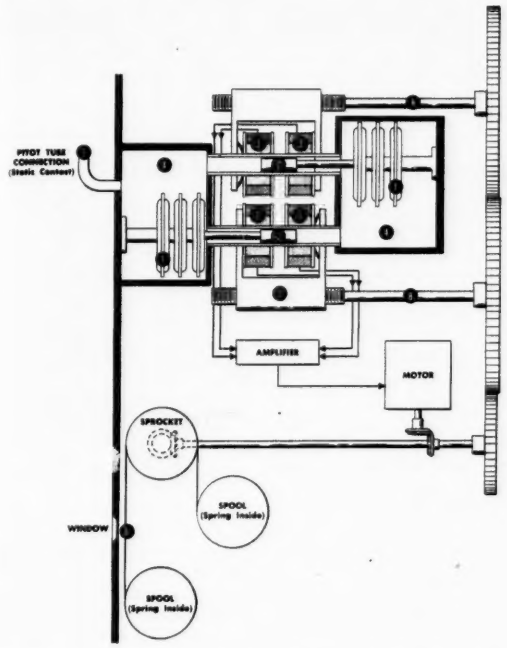
GENERAL CONTROL COMPANY

1205 Soldiers Field Road • • Boston 34, Massachusetts

For more information circle **107** on inquiry card.

Rate Control Altimeter

The Bulova Altitude and Rate Control Altimeter is a new type of pressure sensitive instruments, incorporating the Melchior principles . . . . Six Melchior capsules (1) are



mounted in two opposed groups of three. A soft iron armature (2) moves in the center of a pair of coils (3) The outside air pressure which is to be measured is communicated to the capsule chambers (4) by way of a pressure connection and tube (5) connected to the outside static pressure tube. Increasing altitude causes all the capsules to expand.

The output from the coils is taken to the amplifier which actuates the indicating servo motor which drives the tape and the coils of the inductance bridge. The coils are carried in frames (7) independently moved from right or left by two lead screws (8). Geared together and driven in opposite directions by the same motor, this forms a feedback system. The effect is, therefore, for the motor to drive the coils a distance equal to that of the capsule displacement.

Altimeter is three instruments in one: Altimeter with accuracy of 5-10 feet at sea level; Altitude Controller with repositioning sensitivity of less than 15 feet at 45,000 feet; Rate Indicator and Controller governs rate of climb and descent. (*From new 4-page brochure "Altitude and Rate Control Altimeter," Bulova Research and Development Laboratories, Inc., Woodside 77, N. Y.*)

For this literature circle **404** on inquiry card.

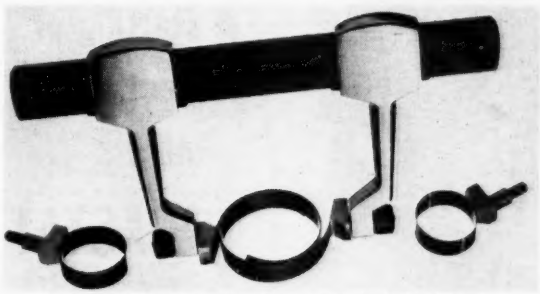
Datatape

The DataTape system is designed to solve the dual problems of multi-point data gathering and rapid and accurate data reduction for recording stress, pressure, temperature and vibration. Standard recorder units are offered with either 14 or 28 recording tracks. The number of data channels which may be recorded on these tracks depends upon the modulation technique employed. Selection of the modulation method is determined by the character of the data to be recorded, the number of channels under consideration, and the accuracies desired.

Recorder flutter is less than 0.2% peak to peak. Re-

THE ROLYN
(Snake) Plier

An indispensable tool for assembly and dismantling of optical, radio, scientific instruments and all kinds of mechanical equipment.



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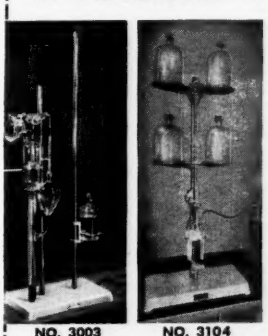

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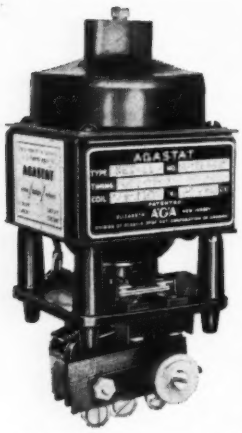

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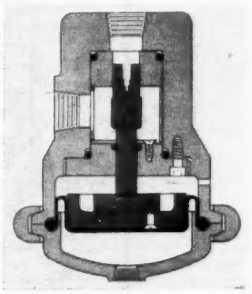
BRIEFS—CONTINUED

cording time is 43 minutes at 10" per second tape speed, or 57 minutes at 7½" per second, using 9¾" reels.

The DataTape Recorder is provided either with two 7-track, interleaved recording heads for 14-channel operation, or two 14-track interleaved heads for 28-channel operation. (*From new 12-page Bulletin 1561A, Consolidated Engineering Corp., 300 North Sierra Madre Villa, Pasadena 15, Calif.*)

For this literature circle **405** on inquiry card.

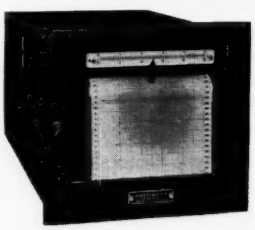
Micro Delta p Controller



The Micro Delta p Controller is a back pressure control system complete in one unit. It serves both as the pressure sensing element, the control pilot and the control valve.

The Controller consists of a Bellofram mounted in a housing at the top, which is connected by a valve stem to the valve plug . . . This is a long stroke, rolling convolution diaphragm with the important characteristic that it maintains exactly constant area throughout its stroke. A pressure from a precision regulator is loaded onto the top side of the Bellofram. The amount of this air pressure is proportional to the back pressure maintained by the Micro Delta p Controller . . . The valve plug is a piston type plug with ports similar to conventional V-Port construction, except that the ports are stepped rather than smooth sided.

space saver RECORDER at lower cost



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The Westronic Model 2705 miniature potentiometer solves your recording needs and control panel space problems. Here are some of the features.

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- ★ **Weighs approximately 25 lbs.**
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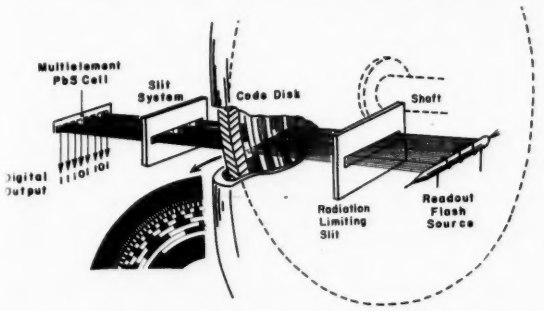
For more information circle **113** on inquiry card.

The back pressure maintained by the Micro Delta p Controller is determined by the area ratio between the valve plug and the Bellofram. There are three standard ratios available . . . . The standard ratios are 6-1, 12-1, and 18-1. This means that each psi of air pressure applied to the top of the Bellofram will increase the back pressure maintained by the Micro Delta p Controller in the 18-1 ratio, for example, by 18 psi. (*From 8-page Bulletin No. 542, Industrial Engineering Corp., Louisville, Ky.*)

For this literature circle **406** on inquiry card.

Shaft-Position Encoders

An extremely compact, direct-reading, shaft-position encoder is described. A cyclical-binary code, expressed as



clear and opaque areas in concentric rings, is printed photographically on a glass disc. A gas-discharge lamp placed radially to cover all channels is flashed periodically. The radiation transmitted through the disc causes voltage pulses, treated as binary ONEs, to be generated by those elements of a multielement PbS cell on which the light falls. Cell elements shielded by opaque areas of the code

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For more information circle **117** on inquiry card.

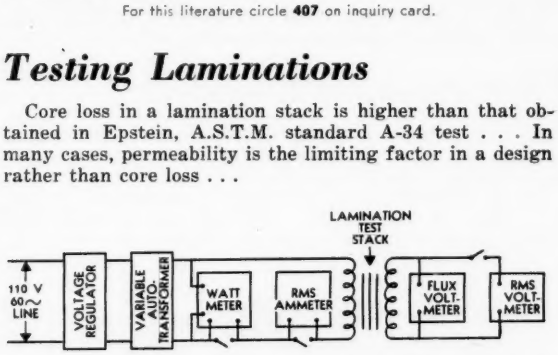
BRIEFS—CONTINUED

disc give no signal, a binary ZERO. Methods are described for serializing and converting the output to binomial-binary code. Sine-cosine codes are also described. (*From new 6-page Bulletin ECA CN309-2, Electronics Corp. of America, Cambridge, Mass.*)

For this literature circle **407** on inquiry card.

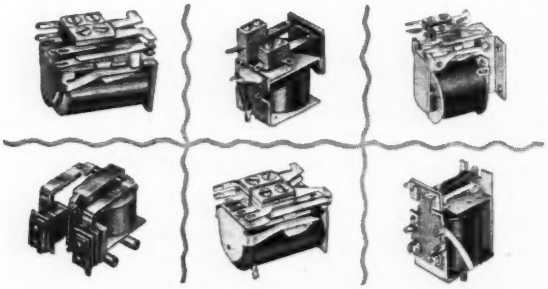
Testing Laminations

Core loss in a lamination stack is higher than that obtained in Epstein, A.S.T.M. standard A-34 test . . . In many cases, permeability is the limiting factor in a design rather than core loss . . .



Thomas & Skinner has taken steps to provide . . . complete quality specifications. Test data on standard E-I laminations are taken of each production lot of laminations, for core loss in units of watts per pound and permeability in terms of volt-amperes per pound at a test flux density of 10,000 gauss and a frequency of 60 cycles.

The test circuit . . . is nearly self-explanatory. A low power factor type wattmeter provides several voltage ranges. The ammeter and RMS voltmeter are thermal instruments, giving true RMS values. The flux voltmeter is an average-reading voltmeter, calibrated to read 1.11 times the average voltage (RMS volts for a true sine wave).



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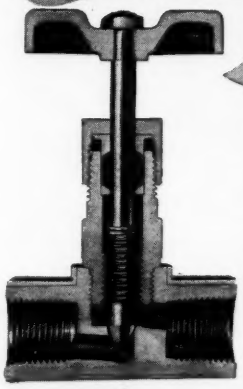

All the superior dependability of the Marsh Needle Valve . . . with all the corrosion resistance and durability of 416 Stainless Steel! Guaranteed for working pressure up to 10,000 psi; equally efficient at any lower pressure. Globe and angle patterns with double female connections in ⅛" to 1" size range. Also globe and angle valves with male inlet, female outlet, ¼" and ½" sizes.

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Marsh Instrument & Valve Co. (Can.) Ltd., 8407 103rd St., Edmonton, Alta., Can.

For more information circle **119** on inquiry card.

Test voltage is determined from the equation $E=4.44 BNAF\times10^{-8}$. Here E is the voltage as read on the flux voltmeter, B is the desired test flux density in gausses, N is the number of turns in the test coil secondary, A is the cross-sectional area in square centimeters of the test stack center leg, and F is the test frequency. Graphs have been plotted of test voltage vs. sample weight for the various sizes of laminations. The wattmeter reading is corrected for power loss caused by the wattmeter current coil resistance, Rw, and the test coil resistance, Rc. The correction which must be subtracted from the total watts is $I^2(Rw+Rc)$ where I is the current read at 10,000 gauss on the ammeter. Dividing the remainder by the weight of the stack in pounds gives the core loss in watts per pound at 10,000 gauss. The products of the true RMS voltage and current, at 1000 gauss and 10,000 gauss, are divided by the weight of the stack in pounds, to obtain the exciting voltamperes per pound at 1000 gauss and 10,000 gauss respectively. (*From* 40-*page Bulletin No. L-355, Thomas & Skinner Steel Products, Inc.,* 1120 *E. St., Indianapolis* 7, *Ind.*)

For this literature circle **408** on inquiry card.

"Kel-Ray" Projectors

Tiny radioactive pellets inside metal capsules are the sources of gamma radiation in "Kel-Ray" projectors. They utilize three radioisotopes as sources of gamma rays: cobalt 60, cesium 137, and iridium 192. The gamma rays given off by radioisotopes make possible industrial radiography without x-ray equipment; but because they cannot be turned off, they require effective shielding.

X-rays and gamma rays are the same kind of radiation, differing only in that they come from different sources . . . It is customary to identify the radiation by its position on the kvp (kilovolt potential) or mev (millions of electron volts) scale. Iridium 192 produces a band of radiation around the 400 kvp point, cesium 137 a sharp line at

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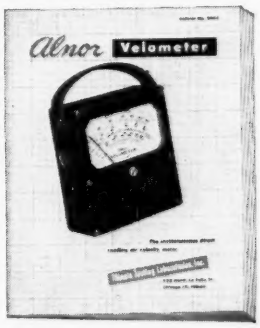

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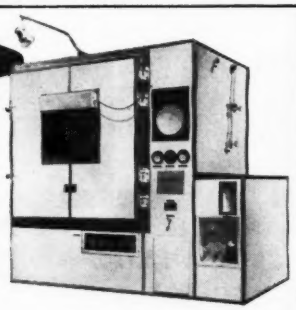

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BRIEFS—CONTINUED

661 kvp, and cobalt 60 two distinct lines at 1170 and 1330 kvp. An important practical difference between radiation produced by x-ray machines and that given off by radioisotopes is that x-rays cover a wide band, while gamma rays are confined to narrow ones. The result is that x-rays have considerably less penetrating power than would be indicated by the kvp rating . . . .

CHARACTERISTICS OF ISOTOPES USED IN "KEL-RAY" PROJECTORS

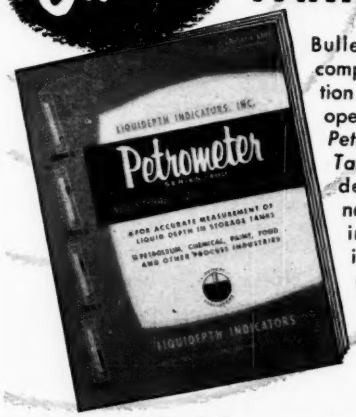
	COBALT 60	CESIUM 137	IRIDIUM 192
Energy mev	1.17, 1.33	0.661	*
Half Life	5.3 years	27 years	75 days
Industrial Life	15 years	80 years	10 months
Maximum Source Strength, Millicuries:			
Model CA	50,000	Limited only by bulk of source	Limited only by bulk of source
Model CB	5,000		100,000
Model CC	Not Recommended		1,600

*Cluster or band from 0.2 to 0.6 mev, with peaks at 0.3, 0.5 and 0.6 mev.

"Kel-Ray" projector Model CA contains a 50-curie cobalt 60 source, capable of radiographing 6-inch-thick steel in 6 minutes . . . Model CB weighs about 250 pounds and is designed to contain a 100,000 millicurie source of iridium 192 . . . . Model CC can be carried and positioned by hand . . . . The millicurie, a measure of the activity of a radioisotope, is 37,000,000 disintegrations per second. (*From new 24-page brochure "Kel-Ray Projectors," Metal & Thermit Corp.*, 100 *E. 42 St., N. Y. 17, N. Y.*

For this literature circle **409** on inquiry card.

How to Choose THE RIGHT REMOTE READING TANK GAUGE



Bulletin 6004 presents comprehensive information on the selection and operation of the *New Petrometer Series 1400 Tank Gauges.* It also describes the many new design features incorporated in the indicators to provide quick, easy installation, trouble-free automatic operation and accurate indication.

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For more information circle **125** on inquiry card.

Standard Time and Frequency Broadcasts

WWV-WWVH TEN-MINUTE TRANSMISSION CYCLE

The standard time and frequency transmissions of the National Bureau of Standards radio stations WWV and WWVH provide an invaluable service to laboratories and individual experimenters throughout the world. Extremely precise audio and radio frequency standards, as well as accurate time intervals and radio frequency propagation warnings, are placed at the disposal of anyone having a receiver capable of tuning to one or more of the transmitting frequencies . . . Operated by the Central Radio Propagation Laboratory of the National Bureau of Standards, Station WWV is located at Beltsville, Md. (near Washington, D. C.), and WWVH is on the island of Maui, Hawaiian Islands. Both stations broadcast continuously on the carrier frequencies and with the output powers shown.

The accuracies of the audio and radio frequencies and other information broadcast by stations WWV and WWVH are as great as the present state of the engineering art will permit. All frequencies transmitted from both stations are accurate to within 2 parts in one-hundred million . . .

The simplest and most direct way of utilizing standard frequency transmissions is the use of the transmitted signals as check points to calibrate the dial of a receiver. (*From* 4-*page Bulletin G2, Specific Products,* 14514 *Dickens St., Sherman Oaks, Calif.*)

For this literature circle **410** on inquiry card.

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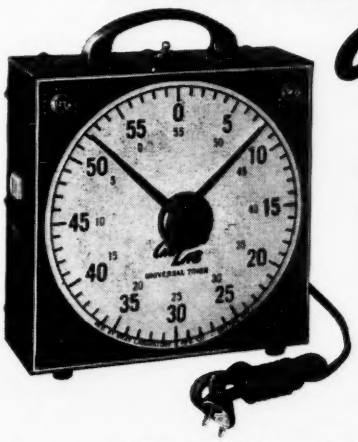

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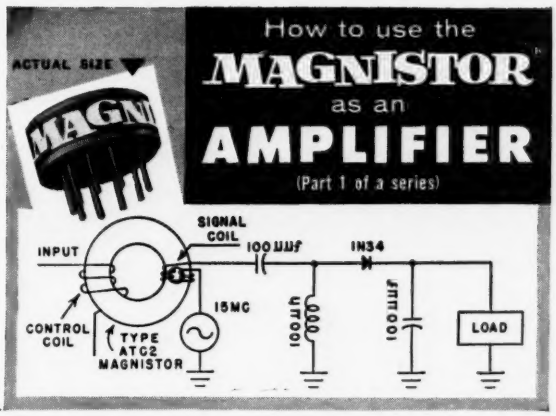

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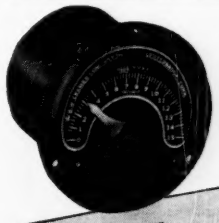
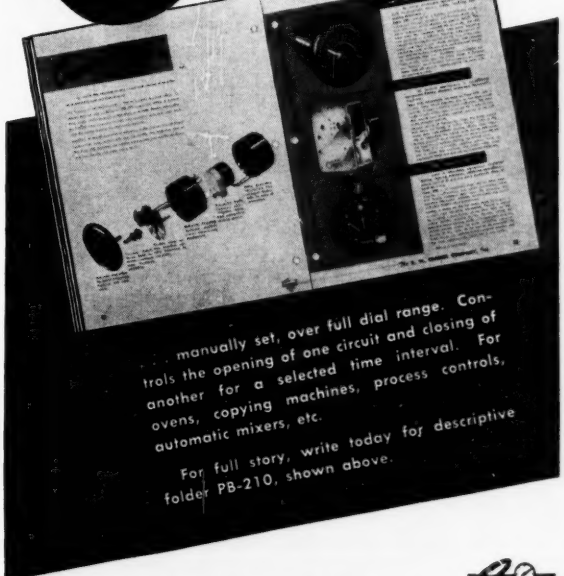


Cramer INTERVAL TIMERS



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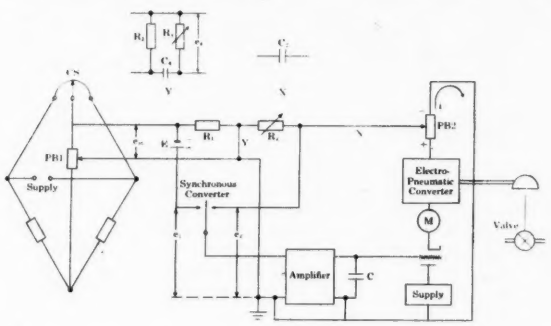
BRIEFS—CONTINUED

Electro-Pneumatic Converter

The 10970 Electro-Pneumatic Converter changes a current input into an air output which actuates a pneumatic control valve. Operating on the force-balance principle, this converter is so sensitive that it has a dead band of



less than 0.1%. Current output of the control unit if fed to a coil of wire suspended in a permanent magnet field where it is converted to a mechanical force on one of a balance beam. On the other side of the fulcrum is a bellows which converts output air pressure into a mechanical force on the balance beam. In this null-balance system, a nozzle at one end of the beam detects the force differential between the bellows and the coil. As the differential moves the beam with respect to the nozzle, the back pressure of the nozzle varies the pneumatic output of a built-in boster which rebalances the beam, and at the same time operates a valve or valve positioner on a process unit.

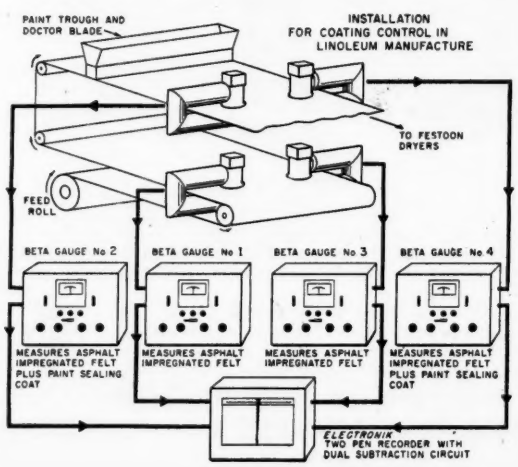
The circuit, above, without inserts at X and Y will provide proportional action only. Inserts "Y & X" provide reset and rate. (*From new 6-page Folder ND4(8), Leeds & Northrup Co., 4907 Stenton Ave., Phila. 44, Pa.*)

For this literature circle **411** on inquiry card.

Beta Gages

Beta Gages operate on the principle that beta ray absorption is proportional to thickness of material or weight per unit area. The complete gaging system consists of a radioactive source of beta rays, a detector, bridge and amplifier circuit, and the ElectroniK recorder or controllers.

Among the current applications are: Paper Making,


PAINT TROUGH AND DOCTOR BLADE
INSTALLATION FOR COATING CONTROL IN LINOLEUM MANUFACTURE
TO FESTOON DRYERS
FEED ROLL
BETA GAUGE No 2
BETA GAUGE No 1
BETA GAUGE No 3
BETA GAUGE No 4
MEASURES ASPHALT IMPREGNATED FELT PLUS PAINT SEALING COAT
MEASURES ASPHALT IMPREGNATED FELT
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The use of beta radiation rather than X-rays or gamma radiation offers the following advantages: (1) beta radiation is absorbed more rapidly and therefore provides a much more sensitive measuring means; (2) the radioactive source is adequately stable without the complicated stabilizing circuits required with X-ray gages; (3) beta radiation absorption is primarily a function of weight per unit area, and depends less on atomic number than either X-rays or gamma radiation; (4) beta radiation has greater ionizing properties, hence a much weaker flux of radiation can be used.

Strontium-90 (a metal made artificially radioactive, whose atomic number is 90) is used as the radioactive source material.

Cesium-137, because its somewhat lower energy gives more sensitivity when used on thin, light sheets, is the radioactive source material used in the Models BG-5 and BG-2/5.

Ruthenium-106 is sometimes used in place of strontium-90. (*From 4-page Instrumentation Data Sheet No. 10.9-la, Minneapolis-Honeywell Regulator Co., Industrial Div., Philadelphia 44, Pa.*)

For this literature circle **412** on inquiry card.

Balanced Valve Regulators

High and Low Pressure Balanced Valve Regulators can be adapted to many special arrangements to satisfy performance requirements. This is particularly true when a small pilot regulator is used to control the operation of the main regulator. By installing large volume regulators in series or in parallel, it is possible to obtain various degrees of safety in case of regulator failure. (*From new 36-page Bulletin 1094, Rockwell Mfg. Co., Pittsburgh 8, Pa.*)

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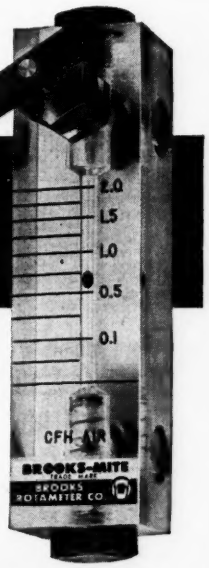

NEW BROOKS-MITE DESIGN... RUGGED... AT LOWEST COST

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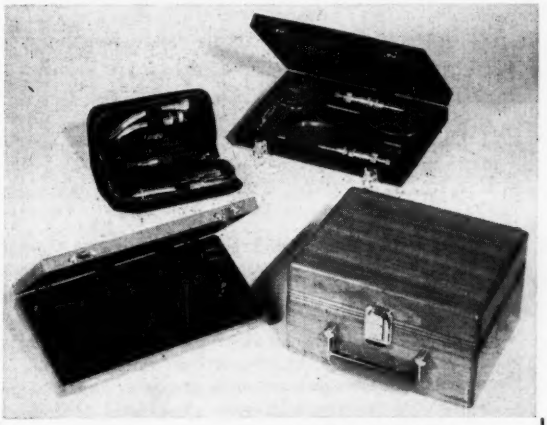

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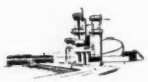
INSTRUMENTS and AUTOMATION

New Literature

AUTOMATION



Machine Tool Control. New 22-page bulletin describes maker's systems and numerical programming system for control of power machine tools.—Automation Corporation of America, 5546 Satsuma Ave., N. Hollywood, Calif.

Circle **414** on inquiry card.

Process Control, Pneumatic Transmitter. New 32-page issue of "Instrumentation" (Vol. 8 No. 3) features several articles on process instrumentation, including article on "Tel-O-Set" transmitter for pressure measurement.—Industrial Div., Minneapolis-Honeywell Regulator Co., Phila. 44, Pa.

Circle **415** on inquiry card.

Process Control Systems. New 12-page descriptive Bulletin 7202 illustrates maker's 'Tel-O-Set" quick-connect line of unitized instruments for all process control problems.—Minneapolis-Honeywell Regulator Co., Industrial Div., Philadelphia 44, Pa.

Circle **416** on inquiry card.

Research & Engineering Progress. New 64-page issue of "General Electric Review" (Jan. 1956) describes advances made in research, nucleonics, industry, electronics, aviation, etc. during 1955.—General Electric Co., Schenectady, N. Y.

Circle **417** on inquiry card.

Injection Molder Control. New 4-page issue of "Wheelco Comments" (No. 6, Vol. 15) describes control system of "world's largest injection molder."—Barber-Colman Co., Rockford, Ill.

Circle **418** on inquiry card.

Logging Control System. New 14-page Bulletin 98268 describes maker's new "TransScanLog" control system.—Taylor Instrument Companies, 95 Ames St., Rochester 1, N. Y.

Circle **419** on inquiry card.

VALVES, ACTUATORS

Explosive Valves. New 4-page illustrated Catalog 5501-XV describes maker's explosive valves that operate on the firing of a small contained explosive squib.—Conax Corp., 7811 Sheridan Dr., Buffalo 21, N. Y.

Circle **420** on inquiry card.

Valve Actuator. New 4-page Bulletin 200 describes maker's electro-hydraulic valve actuator.—Askania Regulator Co., 240 E. Ontario St., Chicago 11, Ill.

Circle **421** on inquiry card.

Valves. New 8-page booklet describes maker's solenoid operated, pilot controlled, air, water, and oil valves.—Barksdale Valves, 5125 Alcoa Ave., Los Angeles 58, Calif.

Circle **422** on inquiry card.

Hydraulic Valves. New 8-page Catalog 261 illustrates and describes solenoid controlled and panel mounted hydraulic valves.—Rivett Lathe & Grinder, Inc., Brighton 35, Boston, Mass.

Circle **423** on inquiry card.

Water Mixing Valves. New 4-page Bulletin 246-A describes maker's "Vernatherm" water mixing valves.—Detroit Controls Corp., 5900 Trumbull Ave., Detroit 8, Mich.

Circle **424** on inquiry card.

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Motorized Valves. New 4-page brochure describes maker's motorized valves for controlling flow of steam and liquids of non-corrosive nature, featuring oil-immersed reversing electric motors.—Au-Tem-Co. Corp., 657 Broadway, New York 12, N. Y.

Circle **425** on inquiry card.

Power Actuator. New 12-page Bulletin B-102 describes maker's 230° high-torque oscillating power actuator, hydraulic or pneumatic operated.—Roto-Mation Motors, Inc. 5255 Riverside, St. Clair, Mich.

Circle **426** on inquiry card.

Valves. New 28-page catalog pictures and describes maker's stainless-steel needle valves, Monel-metal needle valves, globe-type brass valve, pet cocks, gage glass fittings, etc.—Dragon Engineering Co., 5815-17 S. Central Ave., Los Angeles 11, Calif.

Circle **427** on inquiry card.

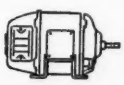
Steam Traps. New 12-page Bulletin T-9 describes maker's piping diagram and steam trap selector for chemical processing equipment.—Yarnall-Waring Co., Chestnut Hill, Philadelphia 18, Pa.

Circle **428** on inquiry card.

Solenoid Valves. New 2-page Bulletin 89 describes maker's "Types H and HR" full-port solenoid valves.—Magnatrol Valve Corp., 67 5th Ave., Hawthorne, Calif.

Circle **429** on inquiry card.

MOTORS,



D-C Motors. New 12-page Brochure GEA-6068 illustrates maker's complete line of fractional-hp d-c motors and equipment.—General Electric Co., Schenectady 5, N. Y.

Circle **430** on inquiry card.

Servo Motor. New 2-page bulletin describes maker's "Class H" 400-cycle servo motor "Type 171".—Servomechanisms, Inc., 625 Main St., Westbury, L. I., N. Y.

Circle **431** on inquiry card.

Motor Controls. New 8-page issue of "Experimenter" (Vol. 30, No. 5) describes maker's "Variac" speed controls in 1 and 1½ hp ratings.—General Radio Co., 275 Massachusetts Ave., Cambridge 39, Mass.

Circle **432** on inquiry card.

Motors. New 4-page issue of "Bodine Motorgram" (Vol. 36, No. 1) describes application of maker's motors in "Model PA-5" automatic breakdown tester.—Bodine Electric Co., 2250 W. Ohio St., Chicago 12, Ill.

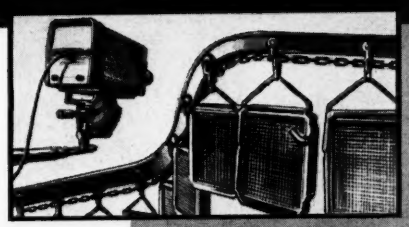
Circle **433** on inquiry card.

TEMPERATURE

Thermistors. New 40-page Data Book V42 presents historical background, operating characteristics, applications and engineering data on

LET DIAMOND UtiliVue INDUSTRIAL TELEVISION SYSTEM

Do the "WATCHING and WAITING"



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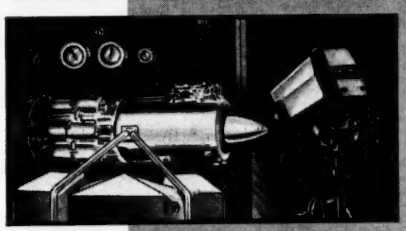
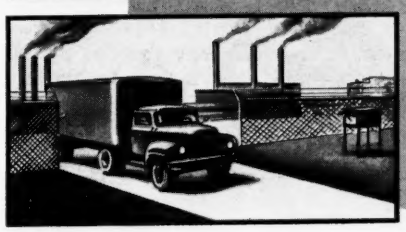


Processes which are too dangerous for direct observation may be watched safely by "UtiliVue". This includes destructive tests of machines, tests of explosives, atomic operations, etc.



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For more information circle **135** on inquiry card.

NEW LITERATURE

thermistors.—Victory Engineering Corp., Springfield Rd, Union, N. J.
Circle **434** on inquiry card.

Resistance Temperature Detectors. New 8-page Brochure 3016D describes maker's temperature-sensitive elements used with indicating, recording controlling and monitoring equipment —Thomas A. Edison, Inc., Instrument Div., W. Orange, N. J.
Circle **435** on inquiry card.

Thermostats. New 2-page Bulletin LL-2120 describes maker's line of "Stemco Type D" thermostats.—Stevens Mfg. Co., Inc., Lexington and Mansfield, Ohio.
Circle **436** on inquiry card.

Thermometer Charts. New 6-page leaflet presents charts for recording thermometers "Models 500 and 1000"; also pressure, vacuum and compound recording gages.—Electric Auto-Lite Co., Instrument & Gauge Div., Toledo, Ohio.
Circle **437** on inquiry card.

Temperature Control. New 2-page Data Sheet 8.1-39 describes maker's temperature control system for textile industry.—Minneapolis-Honeywell Regulator Co., Industrial Div., Philadelphia 44, Pa.
Circle **438** on inquiry card.

Surface Thermocouple. New 2-page Bulletin 420 describes maker's "Magne-Kuple" thermocouple which magnetically attaches to measuring surface.—Thermo-Products Co., 177 E. Fairmount Ave., Milwaukee 17, Wisc.
Circle **439** on inquiry card.

Cartridge Heating Units. New 2-page Brochure 101 describes maker's precision cartridge heating units.—Hotwatt, Electric Heating Specialists, 16 Gould St., Danvers, Mass.
Circle **440** on inquiry card.

TIME, COUNT

Timers. Six new 2-page Bulletins (651, 155, 353, 755, 653 and 654) describe maker's electronic delay timers, repeat-cycle timers, and interval timers.—G. C. Wilson & Co., Huntington, W. Va.
Circle **441** on inquiry card.

Counter. New 2-page bulletin describes maker's differential counter which provides a system of count control on conveyors, transfers and machines.—Ralph D. Ernest Associates, 12818 Puritan Ave., Detroit 27, Mich.
Circle **442** on inquiry card.

Counting Machines. New 2-page bulletin describes maker's "Model T-403 Tab-Count" automatic conveyor system for accurate tablet and capsule counting and filling.—Popper & Sons, Inc., 300 Fourth Ave., New York 10, N. Y.
Circle **443** on inquiry card.

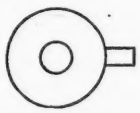
FORCE, WEIGHT

High-temp Pressure Gage. New 4-page Bulletin PG-2 describes maker's "Model C" high-temperature pressure gage for uses to 1000° F.—Callery Chemical Co., Callery, Pa.
Circle **444** on inquiry card.

Pressure Controller. New 2-page Bulletin 7040 describes maker's small-case indicating pressure controller.—Minneapolis-Honeywell Regulator Co., Industrial Div., Philadelphia 44, Pa.
Circle **445** on inquiry card.

Bagging Scales. New 6-page Bulletin 8246A describes and illustrates maker's "Model FFFP" automatic mill bagging scales.—Richardson Scale Co., Van Houten Ave., Clifton, N. J.
Circle **446** on inquiry card.

FLOW, PUMPS



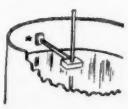
Flow Transmitter. New 2-page Specification Sheet 248 describes maker's differential converter (mercury-less) and liquid-level transmitter, with non-bleed pilot relay.—Minneapolis-Honeywell Regulator Co., Industrial Div., Philadelphia 44, Pa.
Circle **447** on inquiry card.

Flowmeters. New 4-page Specification Sheet 242-2 describes maker's mechanical flowmeters with evenly graduated charts and scales.—Minneapolis-Honeywell Regulator Co., Industrial Div., Philadelphia 44, Pa.
Circle **448** on inquiry card.

Small Pumps. New 4-page folder describes and illustrates maker's complete line of small rotary displacement and centrifugal pumps.—Eco Engineering Co., 12 New York Ave., Newark 1, N. J.
Circle **449** on inquiry card.

Time-Fill Diagram. New 2-page Folder 209 presents diagrams giving time to fill various measures at any given flow rate (gpm).—Hays Mfg. Co., West 12th St., Erie, Pa.
Circle **450** on inquiry card.

LEVEL



Liquid-level Transmitter. New 8-page Bulletin 13-22 describes maker's "Type 13LA" pneumatic liquid-level transmitter.—Foxboro Co., Neponset Ave., Foxboro, Mass.
Circle **451** on inquiry card.

Liquid-Level Control. New 15-page Catalog LC presents maker's complete line of electronic liquid-level controllers.—Deltron, Inc., 2905 N. Leithgow St., Philadelphia 33, Pa.
Circle **452** on inquiry card.

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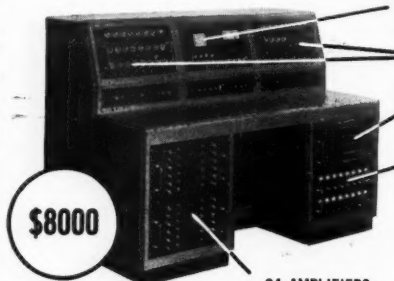

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NEW LITERATURE

COMPUTING, DATA PROCESSING

Digital Computing. New 20-page booklet presents article on the "Logical Design of Digital Computing and Control Circuits with 3C-PACS".—Computer Control Co., Inc., 92 Broad St., Wellesley 57, Mass.

Circle **453** on inquiry card.

Digital Computer. New 4-page leaflet describes application at Allstate Insurance Co. of maker's medium-size digital computer.—ElectroData Corp., 460 Sierra Madre Villa, Pasadena, Calif.

Circle **454** on inquiry card.

Data Processing. New 6-page issue of "Rea-Letter" (#4) presents progress report on company's developments in automatic control and data processing fields.—J. B. Rea Co., 1723 Cloverfield Blvd., Santa Monica, Calif.

Circle **455** on inquiry card.

Data Repeaters. New 6-page Brochure A-2372 describes maker's a-c data repeaters used in aircraft, oil refineries, steam electro power plants, etc.—AC Spark Plug Div., General Motors Corp., 1925 S. Kenilworth Place, Milwaukee 2, Wisc.

Circle **456** on inquiry card.

Data Tape. New 4-page Brochure RS-56-1 describes maker's "Type A" magnetic tape for data processing.—Reeves Soundcraft Corp., 10 E. 52nd St., New York 22, N. Y.

Circle **457** on inquiry card.

Digital Converter. New 8-page leaflet pictures and describes maker's analog-to-digital converters and systems.—J. B. Rea Co., Inc., Santa Monica, Calif.

Circle **458** on inquiry card.

Data-Processing Machines. New 8-page folder pictures and describes maker's data processing machines.—ElectroData Corp., 460 Sierra Madre Villa, Pasadena, Calif.

Circle **459** on inquiry card.

Analog Computer. New 6-page illustrated brochure describes maker's analog computer and gives technique

for use.—Weber Aircraft Corp., 2820 Ontario St., Burbank, Calif.
Circle **460** on inquiry card.

Punch-Tape Filing Equipment. New 4-page brochure describes maker's tape filing equipment for storing punched tape.—Dresser Products, Inc., Providence 5, R. I.
Circle **461** on inquiry card.

Analog Computer. New 2-page specification sheet presents data on maker's desk model analog computer. —Control Specialists, Inc., 115 E. Arbor Vitae St., Inglewood 1, Calif.
Circle **462** on inquiry card.

Tape Handler. New 4-page Booklet 1553APH pictures and describes maker's universal tape-minder for message-tape handling developed for communications systems.—Cycle Equipment Co., 420 Market St., San Francisco 11, Calif.
Circle **463** on inquiry card.

NUCLEONICS

Nuclear Reactors. New 16-page booklet "Nuclear Reactor Data" presents pertinent data on every known nuclear reactor in the world.—Raytheon Mfg. Co., Waltham 54, Mass.
Circle **464** on inquiry card.

Projectors. New 4-page Bulletin P-196 describes and illustrates "Kel-Ray" projectors for industrial radiography with gamma rays.—Metal & Thermit Corp., 100 E. 42nd St., New York 17, N. Y.
Circle **465** on inquiry card.

Nuclear Proportional Counting. New 4-page Bulletin PCC-14 pictures and describes maker's self-powered "PCC-14" proportional counter converter for converting any scaler into a proportional counter for alpha, beta, and gamma.—Nuclear Measurements Corp., 2460 N. Arlington Ave., Indianapolis 18, Ind.
Circle **466** on inquiry card.

Uranium Detector. New 2-page bulletin pictures and describes maker's "Urani-Tector" uranium detector kit. —CMG Industries, 615 S. 2nd., Laramie, Wyoming.
Circle **467** on inquiry card.

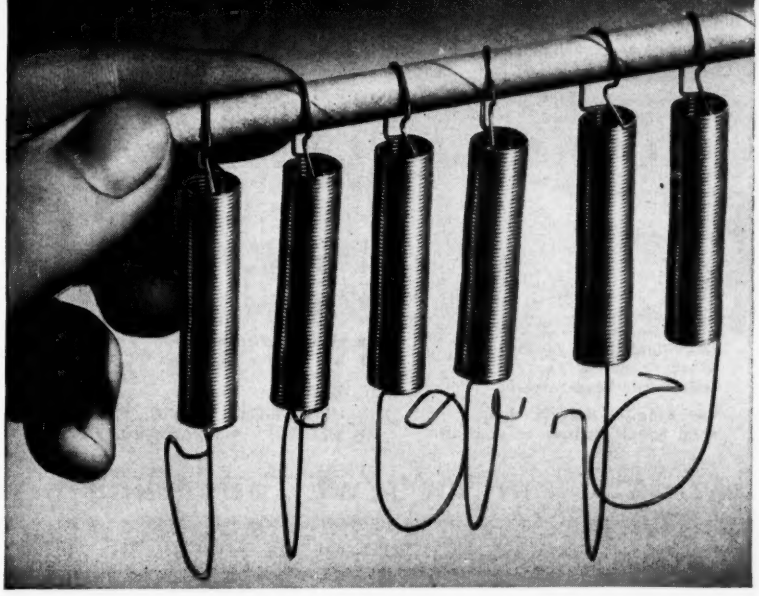
Dosimeter. Two new 2-page data sheets describe maker's "Radad" exposure dosimeter.—Electromation Co., 116 S. Hollywood Way, Burbank, Calif.
Circle **468** on inquiry card.

RECORDING

Data Recording Camera. New 44-page brochure pictures and describes maker's "V-10" 35-mm camera for recording data in aircraft, missiles, etc. —Pacific Laboratories, 12808 Venice Blvd., Los Angeles 66, Calif.
Circle **469** on inquiry card.

Recording Cameras. New 40-page booklet describes and illustrates mak-

We'll Help You Put More "Automatic" In Your Automation!



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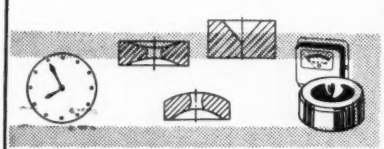

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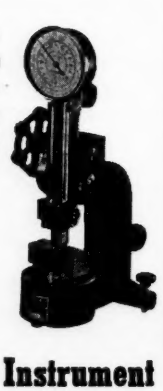

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er's high-speed data-recording cameras for military and industrial use.—Traid Corp., Sherman Oaks, Calif.

Circle **470** on inquiry card.

LAB APPARATUS

Distillation Units. New 4-page illustrated Brochure 716 describes maker's "Front View" distillation units for petroleum products.—Precision Scientific Co., 3737 W. Cortland St., Chicago 47, Ill.

Circle **471** on inquiry card.

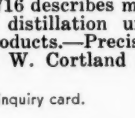
Sterilizers. New 2-page bulletin describes maker's pressure sterilizers and accessory equipment.—Aetna Scientific Co., Corner Second & Spring Sts., Everett 49, Mass.

Circle **472** on inquiry card.

Sterilizer. New 2-page bulletin describes maker's "ST-S" hi-speed compact sterilizer used in laboratories, hospitals, etc.—Aetna Scientific Co., Corner Second and Spring Sts., Everett 49, Mass.

Circle **473** on inquiry card.

ANALYTICAL



Spectrophotemetry, Leak Detection. New 8-page issue of "Beckman Bulletin" (No. 17) features articles on maker's radio frequency leak detector, automatic spectrophotometers, new pH electrode, etc. Beckman Div., Beckman Instruments, Inc., Fullerton, Calif.

Circle **474** on inquiry card.

Spectrophotometry. New 4-page Bulletin 469 is a form for analysis of laboratory spectrophotometer needs.—Beckman Div., Beckman Instruments, Inc., Fullerton, Calif.

Circle **475** on inquiry card.

NMR Spectrometer. New 2-page bulletin describes maker's nuclear magnetic resonance spectrometer.—Varian Associates, 611 Hansen Way, Palo Alto, Calif.

Circle **476** on inquiry card.

pH Meter Tester. New 4-page Bulletin 138 describes maker's "Model 25" pH meter tester for testing pH instruments.—Photovolt Corp., 95 Madison Ave., New York 16, N. Y.

Circle **477** on inquiry card.

Fluorescence Meter. New 2-page Bulletin 392 describes maker's "Model 540" multiplier fluorescence meter for fluorometric analysis.—Photovolt Corp., 95 Madison Ave., New York 16, N. Y.

Circle **478** on inquiry card.

Titanium Analysis. New 4-page issue of "Spectrographer's Newsletter" (Vol. 8, No. 4) features article on "Recent Advances in Titanium Anal-

ysis".—Applied Research Laboratories, P. O. Box 1710, Glendale 5, Calif.
Circle **479** on inquiry card.

Gas Chromatography. New 8-page booklet is article on "Adsorption Fractionation of Gases and Vapors".—Burrell Corp., 2223 Fifth Ave., Pittsburgh 19, Pa.
Circle **480** on inquiry card.

Spectrographic Standards. New 12-page Catalog 55F describes and illustrates maker's spectrographic standards, accessories and supplies.—Spex Industries, Inc., 80-56 230th St., Queens Village 27, N. Y.
Circle **481** on inquiry card.

DIMENSIONAL GAGING

Block Gage Control. New 80-page brochure is paper by F. H. Rolt on "Use of Light Waves for Controlling Accuracy of Block Gages."—Engis Equipment Co., 431 S. Dearborn St., Chicago 5, Ill.
Circle **482** on inquiry card.

Gage Blocks. New 34-page Catalog 56 describes maker's gage blocks and accessories.—Webber Gage Co., 12900 Triskett Rd., Cleveland 11, Ohio.
Circle **483** on inquiry card.

TESTING

Paint, Paper, Rubber Test Instruments. New 96-page 1956 catalog describes instruments for testing paint, rubber, paper, plastics, ceramics, oil, leather, food and other materials for production plant and laboratory use.—Gardner Lab., Inc., Bethesda, Md.
Circle **484** on inquiry card.

Universal Testing Machines. New 12-page Bulletin 4401 describes and illustrates the Baldwin-Tate-Emery universal testing machines.—Baldwin-Lima-Hamilton Corp., Phila. 42, Pa.
Circle **485** on inquiry card.

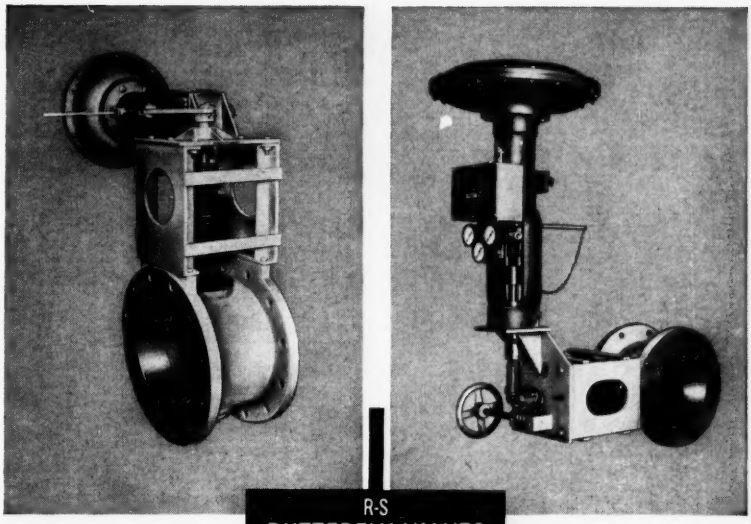
Test Centrifuge. New 2-page Bulletin CR-180 pictures and describes maker's test centrifuge.—Coleman Engineering Co., Inc., 6040 W. Jefferson Blvd., Los Angeles 16, Calif.
Circle **436** on inquiry card.

ELECTRICAL, ELECTRONIC INSTRUMENTS

Choppers. New 20-page Bulletin 103 describes theory and application of maker's contact modulator for producing modified square waves.—Airpax Products Co., Middle River, Baltimore 20, Md.
Circle **487** on inquiry card.

Digital Voltmeter. New 4-page Brochure A-2374 describes maker's "Auto Count" for digital readings of milliamperes or millivolts.—AC Spark Plug Div., General Motors Corp., 1925 E. Kenilworth Place, Milwaukee 2, Wisc.
Circle **488** on inquiry card.

Volt-Ohmmeter. New 2-page bulletin describes maker's "Model 355 Mid-



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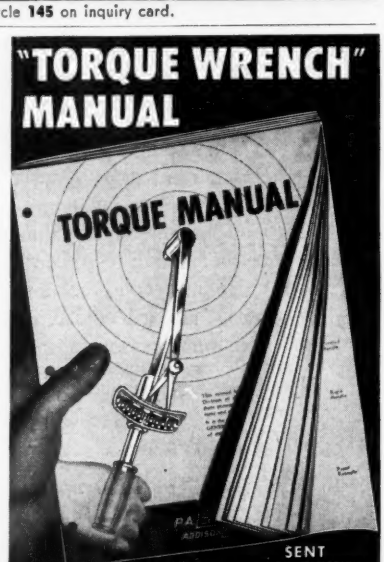


For more information circle **147** on inquiry card.

NEW LITERATURE

getester" volt-ohmmeter.—Simpson Electric Co., 5200 W. Kinzie St., Chicago 44, Ill.

Circle **489** on inquiry card.

Ohmmeter. New 2-page bulletin describes maker's "Model LRO" low-resistance ohmmeter for measuring resistance of sensitive relay contacts, fuses, bus bars and connections.—Industrial Instruments, Inc., 89 Commerce Rd., Cedar Grove, Essex County, N. J.

Circle **490** on inquiry card.

Oscilloscope. New 4-page bulletin presents maker's "Model 411 Easy-Six" oscilloscope for electronic research etc.—Laboratory for Electronics, Inc., 75 Pitts St., Boston 14, Mass.

Circle **491** on inquiry card.

Test Instruments. New 12-page 1956 catalog describes 54 of maker's electronic test instruments in both kit and factory-wired form.—Electronic Instrument Co., Inc., 84 Withers St., Brooklyn 11, N. Y.

Circle **492** on inquiry card.

Pulse Testing. New 6-page issue of "H-P Journal" (Vol. 7, No. 3) features article on "Square Wave and Pulse Testing of Linear Systems".—Hewlett-Packard Co., 275 Page Mill Rd., Palo Alto, Calif.

Circle **493** on inquiry card.

VTVM. New 4-page issue "HP Journal" (Vol. 7, No. 4) features article on "An Enhanced Accuracy High Readability VTVM".—Hewlett-Packard Co., 275 Page Mill Rd., Palo Alto, Calif.

Circle **494** on inquiry card.

Test Instruments. New 12-page Catalog 23 illustrates and describes maker's complete line of electronic test instruments for industrial and radio-TV-communications, etc.—Precision Apparatus Co., Inc., 70-31 84th St., Glendale 27, L. I., N. Y.

Circle **495** on inquiry card.

Voltmeters, Test Instruments. New 20-page Catalog 55G-U describes and illustrates maker's Voltmeters, Megohm test units, laboratory standard meters, shunts, phase sequence indicators, etc.—Davenport Mfg. Co., 1713 N. Ashland Ave., Chicago 22, Ill.

Circle **496** on inquiry card.

Low-ohm Bridge. New 10-page booklet describes maker's "KS-2119" low-ohm bridge for measuring low-ohmmages to accuracy of 0.25%.—Kell-Strom Tool Co., Inc., 214 Church St., Wethersfield, Conn.

Circle **497** on inquiry card.

Volt-Ohm Meter. New 4-page booklet describes maker's "Meter-Matic" vacuum-tube volt-ohm meter.—Leitch Engineering Co., 326 Lincoln St., Manchester, N. H.

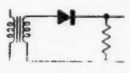
Circle **498** on inquiry card.

Amplifiers, Transformers. New 8-page booklet describes maker's transformers and reactors, broadcast amplifiers, power supplies, etc.—Lange-

vin Mfg. Corp., 47-37 Austell Place, Long Island City 1, N. Y.
Circle **499** on inquiry card.

Voltage Tester. New 2-page illustrated bulletin presents specifications of maker's #61-007 glow-tube-type voltage tester for testing high-voltage circuits—110 v, 220 v, 440 v, 600 v.—Ideal Industries, Inc., Sycamore, Ill.
Circle **500** on inquiry card.

POWER SUPPLIES



Power Supply. New 2-page descriptive bulletin illustrates maker's "Model MR532-15A" magnetic amplifier, tubeless, regulated d-c power supply.—Perkin Engineering Corp., 345 Kansas St., El Segundo, Calif.
Circle **501** on inquiry card.

D-C Power Supplies. New 4-page Catalog PS 11-15-55 describes maker's complete line of transistor and tubeless power supplies, including regulated d-c supplies and constant-current generators.—Electronic Research Associates, Inc., 67 E. Center St., Nutley 10, N. J.
Circle **502** on inquiry card.

High Power A-C Supplies. New 2-page data sheet presents specifications for maker's electronic power supplies for shakers, etc. Featuring frequency ranges up to 3000 cps and peak output to 400,000 watts.—LM Electronics, Inc., 5017 Exposition Blvd., Los Angeles 16, Calif.
Circle **503** on inquiry card.

Selenium Rectifiers. New 12-page Bulletin ER-107 describes and illustrates maker's selenium rectifiers for electroplating, anodizing and related processing.—Hanson-Van Winkle-Munning Co., Church St., Matawan, N. J.
Circle **504** on inquiry card.

Germanium Rectifiers. New 4-page bulletin describes maker's "Sel-Rex" germanium rectifiers.—Bart-Messing Corp., 229 Main St., Belleville 9, N. J.
Circle **505** on inquiry card.

AIR, VAPOR

Water Vapor Measurement. New 12-page Bulletin 224 features article on "The Measurement of Water Vapor in Air and Other Gases".—Pittsburgh Lectrodryer Corp., P. O. Box 1766, Pittsburgh 30, Pa.
Circle **506** on inquiry card.

Air Meter. New 4-page Bulletin 55 describes maker's "Anemotherm" air meter for measuring air velocity, air temperature and static pressure in heating, ventilating, etc.—Anemostat Corp. of America, 10 East 39th St., New York 16, N. Y.
Circle **507** on inquiry card.

Air Pumps. New 2-page Data Sheet 8-13 describes maker's "Model RG-15180" industrial air pumps.—Lear, Inc., Lear-Romec Div., Elyria, Ohio.
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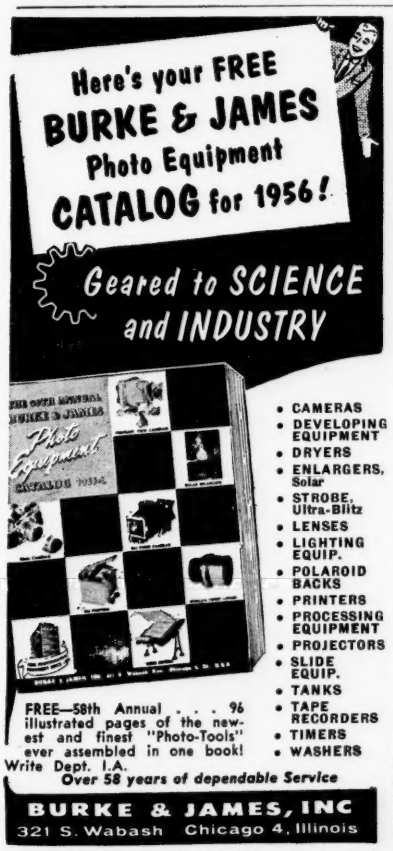

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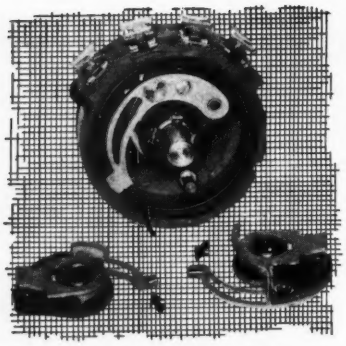

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Maximum Count: Four digits — 9,999	**Pulse output** 50 volts
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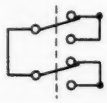
NEW LITERATURE

OPTICAL

Photoelectric Cell. New 24-page booklet presents electrical characteristics of maker's "Ektron" detector, a lead-sulfide photoconductor.—Eastman Kodak Co., Rochester 4, N. Y.

Circle **509** on inquiry card.

RELAYS SWITCHES,



Relays, Switches. New 32-page Catalog R-522-4 describes maker's line of sealed and unsealed relays, stepping switches, keys, switching and control systems and other components for industrial applications.—North Electric Mfg. Co., Galion, Ohio.

Circle **510** on inquiry card.

Switches. New 4-page issue of "Uses Unlimited" (Vol. 9, No. 4) describes maker's push-button actuators, environment-proof roller lever switches, counter switch, etc.—Micro Switch Div., Minneapolis-Honeywell Co., Freeport, Ill.

Circle **511** on inquiry card.

Mercury-switch Controls. New 54-page Catalog 856 pictures and describes maker's mercury-switch-equipped pressure controls, temperature controls, relays, etc.—Mercoid Corp., 4201 Belmont Ave., Chicago 41, Ill.

Circle **512** on inquiry card.

Contactors, Relays. New 100-page Catalog 55 describes distributor's line of renewal parts for contactors, relays, etc. Includes 16-page Price List.—Brownell Distributors, Inc., 306 Canal St., New York 13, N. Y.

Circle **513** on inquiry card.

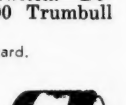
Time-Delay Relays. New 4-page Bulletin SD-1 describes maker's "Agastat" time-delay relays.—A'G'A Elastic Stop Nut Corp. of America, Elizabeth, N. J.

Circle **514** on inquiry card.

Switches. New 4-page Bulletin 263 presents specifications and operational characteristics of maker's "Tyni" miniature snap-acting switch.—Detroit Controls Corp., 5900 Trumbull Ave., Detroit 8, Mich.

Circle **515** on inquiry card.

RESISTORS, POTENTIOMETERS



Potentiometers. New 12-page booklet features article on "General Aspects of Precision Potentiometers."—Potentiometer Div., Fairchild Controls Corp., Hicksville, N. Y.

Circle **516** on inquiry card.

Potentiometers. New 8-page booklet presents article on "Filmpots and their Recent Applications."—Potentiometer Div., Fairchild Controls Corp., Hicksville, N. Y.

Circle **517** on inquiry card.

Potentiometer. Two new 2-page bulletins describe maker's "Model G" translation potentiometers for precision potentiometer pick-ups.—Servonic Instruments, Inc., 1145 S. Fair Oaks, Pasadena 2, Calif.
Circle **518** on inquiry card.

Potentiometer. Two new 2-page bulletins describe maker's "Model 300-00" sub-miniature trimming potentiometer and "Model 303-00" miniature trimming potentiometer.—Daystrom Pacific Corp., Potentiometer Div., 3030 Nebraska Ave., Santa Monica, Calif.
Circle **519** on inquiry card.

Potentiometers. New 4-page booklet pictures and describes maker's "Series 3" precision potentiometers and "Series 7" accelerometers.—Precision Potentiometers, 383 N. Foothill Blvd., Pasadena, Calif.
Circle **520** on inquiry card.

Rheostats. New 2-page Data Sheet N152 presents specifications on maker's "Vitrohm" ring-type rheostats.—Ward Leonard Electric Co., Mount Vernon, N. Y.
Circle **521** on inquiry card.

CONNECTORS

Solderless Fittings. New 4-page Bulletin 561 describes maker's complete line of solderless fittings and electrical hardware products lines.—Buchanan Electrical Products Corp., Hillside, N. J.
Circle **522** on inquiry card.

Connector. New 2-page bulletin describes and illustrates maker's "Series CCC20" miniature connector for airborne electronics.—DeJur-Amsco Corp., 45-01 Northern Blvd., Long Island City 1, N. Y.
Circle **523** on inquiry card.

Connectors. New 4-page booklet presents specifications for maker's compression-loaded contact connectors.—Circon Component Co., 17544 Raymer St., Northridge, Calif.
Circle **524** on inquiry card.

Connectors. New 2-page illustrated bulletin "Application Notes" describes the wiring of maker's "Circon" connectors.—Circon Component Co., 17544 Raymer St., Northridge, Calif.
Circle **525** on inquiry card.

Connector. New 2-page bulletin describes maker's "XLR" audio cord connector.—Cannon Electric Co., 3209 Humboldt St., Los Angeles 31, Calif.
Circle **526** on inquiry card.

Connectors. New 2-page Brochure M1-125-10M describes maker's miniature electrical connectors.—Deutsch Co., 7000 Avalon Blvd., Los Angeles, Calif.
Circle **527** on inquiry card.

MAGNETICS

Electrical Laminations. New 40-page Bulletin L-355 describes maker's electrical laminations for industrial application.—Thomas & Skinner Steel Products, Inc., Indianapolis, Ind.
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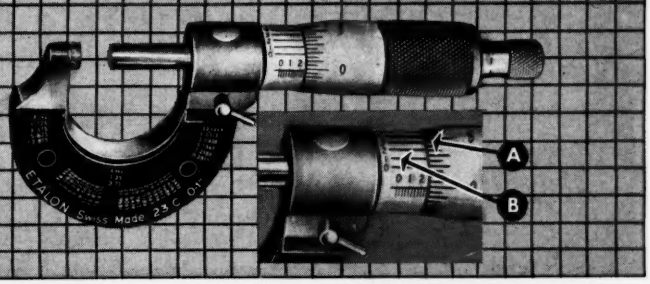

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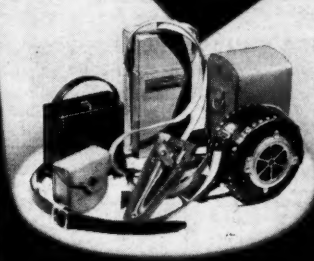

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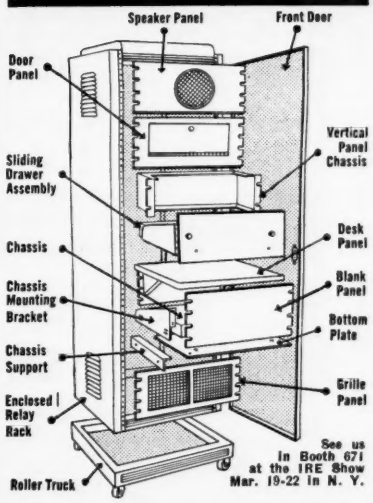

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ELECTRONIC COMPONENTS

Electronic Components. New 60-page illustrated catalog "Mandex Electronic Components" presents data on maker's molded and laminated tube sockets, terminal strips, lugs, plugs, etc.—Mandex Mfg. Co., Inc., 2608 W. 16th St., Chicago 8, Ill.
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Precision Capacitors. New 28-page booklet presents specifications on maker's "Polycon" polystyrene capacitors.—Southern Electronics Corp., 239 W. Orange Grove Ave., Burbank, Calif.
Circle **530** on inquiry card.

Autotransformer. New 12-page issue of "Experimenter" (Vol. 30, No. 7) features article on "The Type W5 Variac—A New and Better Variable Autotransformer."—General Radio Co., 275 Massachusetts Ave., Cambridge 39, Mass.
Circle **531** on inquiry card.

MECHANICAL COMPONENTS

Ball Bearings. New 4-page illustrated brochure describes twenty-one standard types of maker's miniature ball bearings.—Miniature Precision Bearings, Inc., Keene, N. H.
Circle **532** on inquiry card.

Precision Nuts, Screws. New 4-page leaflet describes maker's miniature precision nuts, rivets, eyelets, screws, etc.—Circon Component Co., 17544 Raymer St., Northridge, Calif.
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Constant-Force Springs. New 16-page Bulletin 313A-1-55 presents data on maker's "Flex'ator" constant-force compression spring.—Hunter Spring Co., Lansdale, Pa.
Circle **534** on inquiry card.

Seal Plugs. New 4-page bulletin describes and illustrates maker's "Sure-Seal" hermetic seal plugs.—Seals, Ltd., 1010 Mission St., S. Pasadena, Calif.
Circle **535** on inquiry card.

Retaining Rings. New 4-page booklet pictures and describes maker's stacked retaining rings. Includes 4-page engineering specification data sheet.—Industrial Retaining Ring Co., 8 W. Sidney Ave., Mt. Vernon, N. Y.
Circle **536** on inquiry card.

Bearings, Components. New 2-page Bulletin 6 describes maker's bearings and precision mechanical components. —Halax Corp., 17470 Shelbourne Way, Los Gatos, Calif.
Circle **537** on inquiry card.

Stainless Fasteners. New 52-page stock list and data book presents engineering data on composition, properties, applications and weights of stainless steel fasteners.—Allmetal Screw Products Co., Inc., 821 Stewart Ave., Garden City, L. I. N. Y.
Circle **538** on inquiry card.

Universal Joint. New 2-page bulletin presents specifications on maker's "Mini-Joint" miniature universal joint with zero backlash.—Falcon Machine & Tool Co., Inc., 209 Concord Turnpike, Cambridge 40, Mass.

Circle **539** on inquiry card.

Couplings. New 2-page Bulletin 37-52 describes maker's flexible-disc couplings for power Transmission equipment.—Thomas Flexible Coupling Co., Warren, Pa.

Circle **540** on inquiry card.

TUBING, FITTINGS

Tube Fittings. New 4-page Bulletin 3049 pictures and describes maker's "Nylo-Seal" tube fittings.—Imperial Brass Mfg. Co., 1200 W. Harrison St., Chicago 7, Ill.

Circle **541** on inquiry card.

Piping Design. New 12-page booklet details maker's general methods for analysis of piping flexibility on designing piping layouts.—M. W. Kellogg Co., 225 Broadway, New York, N. Y.

Circle **542** on inquiry card.

MATERIALS

Refractory Insulators. New 6-page bulletin presents data on maker's thermocouple refractory insulators.—Stupakoff Div., The Carborundum Co., Latrobe, Pa.

Circle **543** on inquiry card.

Teflon. New 6-page leaflet describes maker's "Teflon" tapes, sheets, cylinders, slugs, solids, tubes, rods, etc.—Balfor Industries, Inc., 1815 Webster Ave., Bronx 57, N. Y.

Circle **544** on inquiry card.

Potting Compound. New 4-page technical Data Sheets PR-1401-Q presents maker's high-temperature potting compound for electric connectors.—Products Research Co., 3126 Los Feliz Blvd., Los Angeles, Calif.

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Potting Resins (Plus Free Samples). New 2-page bulletin describes and illustrates free sample kits of maker's casting and potting resins available for experimental use by designers, engineers, etc.—Plastronics, P. O. Box 96, Winter Hill 45, Mass.

Circle **546** on inquiry card.

Rubber Goods. New 80-page Design Hand-Book MT-56 presents data on characteristics and uses of maker's rubber and rubber-like products.—Lavelle Rubber Co., 424 N. Wood St., Chicago 22, Ill.

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Insulating Materials. New 32-page Catalog 18 presents data on maker's electrical insulating materials.—Insulation Manufacturers Corp., 565 W. Washington Blvd., Chicago 6, Ill.

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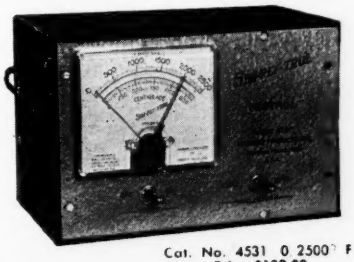

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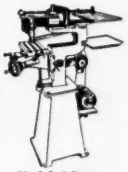

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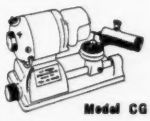

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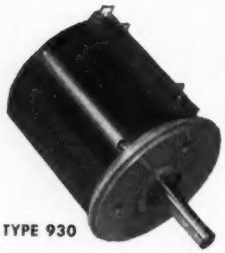

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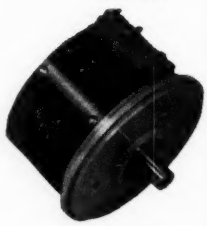

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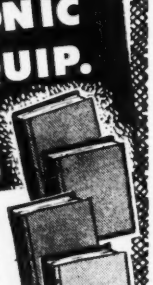

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NEW LITERATURE

Conducting Cements. New 24-page booklet describes maker's "Tracit-100 and 200" conducting cements used to improve heat transfer between tracings and process equipment.—Climax Mfg. Corp., 900 Wilmington Rd., New Castle, Dela.

Circle **549** on inquiry card.

Glass Laminates. New 4-page bulletin contains technical data on maker's "100 Epoxy" glass laminates. 4-page bulletin describes company's research facilities, staff, equipment, etc.—New England Laminates Co., Inc., 16 Dyke Lane, Stamford, Conn.

Circle **550** on inquiry card.

Heat-Resistant Steels. New 54-page booklet presents "Schedule of Extras" presents adjusted base prices to apply on maker's stainless and heat-resisting steels.—Crucible Steel Company of America, The Oliver Bldg., Mellon Square, Pittsburgh 22, Pa.

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Alloys, Precision Strip. New 16-page booklet "Precision Metals Services" describes facilities for producing special alloys, precision strip, etc. —Allied Products Div., Hamilton Watch Co., Lancaster, Pa.

Circle **552** on inquiry card.

Wire. New 24-page price schedule lists wire sizes, tolerances and prices for monel, nickel, inconel, and heat-resisting steels in sizes ½-0.002".—Techalloy Co., Inc., Rahns, Pa.

Circle **553** on inquiry card.

Extruded Rod. New 20-page "Beryl-co" Product Directory lists and describes characteristics of maker's line of beryllium copper, aluminum and nickel alloys, etc.—Beryllium Corp., Reading, Pa.

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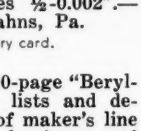
FABRICATION



Dial Graduations. New 4-page illustrated brochure describes maker's dial graduation technique.—Precision Photomechanical Corp., 170-51 S. Van Brunt St., Englewood, N. J.

Circle **555** on inquiry card.

Dip Soldering, Printed Circuits, Cables. Five 2- and 4-page bulletins describe maker's dip-soldering machine, printed circuitry and subminiaturization, cables and wiring harness assemblies, "Model 300-1B" operational amplifier, and facilities.—Electronic Products Corp., 322 State St., Santa Barbara, Calif.

Circle **556** on inquiry card.

Engravers. New 4-page brochure illustrates maker's engraving equipment and components.—Mico Instrument Co., 80 Trowbridge St., Cambridge 38, Mass.

Circle **557** on inquiry card.

Grinding Machines. New 8-page Catalog 200 describes maker's shaft grinding machines and accessories.—Foredom Electric Co., 27 Park Place, New York 7, N. Y.

Circle **558** on inquiry card.

Micro Drills. New 4-page Bulletin Q presents specifications on maker's micro-drills for instrument work, automatic screw machines, watchmakers, etc.—Louis Levin & Son, Inc., 3610 S. Broadway, Los Angeles 7, Calif.

Circle **559** on inquiry card.

Lathes. New 4-page brochure describes maker's 13" toolroom lathes.—South Bend Lathe Works, 425 E. Madison St., S. Bend 22, Ind.

Circle **560** on inquiry card.

Sprayed Metal Coatings. New 6-page Bulletin 120 illustrates and describes sprayed metal coatings used in production of electrical and electronic equipment.—Metallizing Engineering Co., Inc., 1101 Prospect Ave., Westbury, N. Y.

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Wire Stripping. New 4-page Bulletin 4 presents "The Story of Fybrglass Stripping Wheels."—Eraser Co., Inc., 1068 S. Clinton St., Syracuse 4, N. Y.

Circle **562** on inquiry card.

Blowers, Fans, Motors. New set of data sheet inserts for maker's ring-binder catalog covers maker's blowers, motors, fans, etc. Includes nomographs and charts for selection of correct fan size.—Rotron Mfg. Co., Inc., Schoonmaker Lane, Woodstock, N. Y.

Circle **563** on inquiry card.

Precision Machinery. New 4-page leaflet describes maker's tapping machines, cutter grinder, drill-press, ratio pantograph, edging machine, rotary table, paste solder, etc.—Mico Instrument Co., 80 Trowbridge St., Cambridge 38, Mass.

Circle **564** on inquiry card.

Modular Assembly. New 12-page Engineering Bulletin 450 describes maker's "Plexicon" system pin assembly circuit for modular electronic assembly.—Erie Resistor Corp., Erie, Pa.

Circle **565** on inquiry card.

Soldering Fluxes. New 9-page Bulletin 14 describes maker's printed circuit dip soldering fluxes, solders and techniques.—Hi-Grade Alloy Corp., 1236 S. Talman, Chicago, Ill.

Circle **566** on inquiry card

Photo-Marking Process. New 4-page leaflet describes maker's "Lackon" photo-marking process for dials, panels, scales, etc.—Sun Dial Corp., Caldwell, N. J.

Circle **567** on inquiry card.

Coil Winder. New 4-page booklet describes maker's "Model 1BFTHA" automatic field coil winder.—Globe Tool & Engineering Co., Dayton 3, Ohio.

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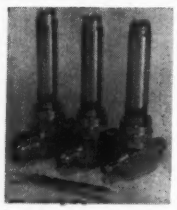

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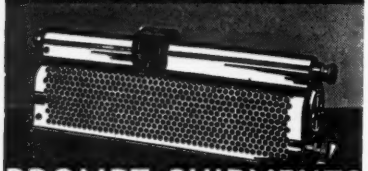

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Advertisers' Index

A'G'A Division of Elastic Stop Nut Corp. of America 360
Aircraft-Marine Products, Inc. 343
Alina Corporation 379
Allen-Bradley Co. 252
American Chain & Cable Co. 326
American Machine & Metals, Inc. 321
American Phenolic Corporation 334
Annin Company ..... IBC
Askania Regulator Company 311
Assembly Products, Inc. 381
Associated Missile Products Corporation 385
Avien, Inc. 336

Bailey Meter Company 239
Baker & Company, Inc. 318, 341, 355
Baldwin-Lima-Hamilton Corporation 255
Barber-Colman Company 226
Barber-Colman Company, Wheelco Instruments Division 226
Barksdale Valves 224
Beckman, Inc., Arnold O. 340
Beede Electrical Instrument Co., Inc. 361
Berkeley Division, Beckman Instruments, Inc. 236
Black, Sivalls & Bryson, Inc. ..... Inside Front Cover
Boonton Radio Corporation 385
Borg Corporation, George W. 345
Bristol Company 246, 299
Brooks Rotameter Company 367
Brown Instruments Division of Minneapolis-Honeywell Regulator Co. 234, 292, 293
Brush Electronics Company 214-215, 216
Burke & James, Inc. 377
Burlington Instrument Co. 380

Cambridge Instrument Co., Inc. 361
Chace Co., W. M. 353
Clare & Co., C. P. 261
Cohn Corp., Sigmund 376
Comar Electric Company 362
Commercial Research Laboratories, Inc. 331
C.O.M.S.I.P. (Instrument Control Consultant) 384
Conoflow Corporation 351
Consolidated Electrodynamics Corporation 242, 312
Cramer Co., Inc., R. W. 365
Crucible Steel Company of America 347
Crystal Glass Tube & Cylinder Co. 380
Curtiss-Wright Corporation 314, 354

Development Engineering Company 364
Diamond Power Specialty Corp. 369
Diehl Manufacturing Company 248
Dietert Co., Harry W. 359
Dimco-Gray Company 365
Doelcam, Division of Minneapolis-Honeywell Regulator Co. 219
Du Mont Laboratories, Inc., Allen B. 258

Eagle Signal Corporation 335
Eastern Air Devices, Inc. 337
Edison, Incorporated, Thomas A. 237
EECO Production Company 332
Electronic Associates Inc. 300
Elgin National Watch Company 203
Emery Company, A. H. 371
Engis Equipment Company 363
Eppley Laboratory, Inc. 227

Fairchild Controls Corporation 382
Falcon Machine & Tool Company 384
Falstrom Company 196
Farris Engineering Corporation 204-205
Fielden Instrument Division 338
Fisher Governor Company 212-213
Ford Instrument Company 328
Foxboro Company 208-209
Frederick and Associates, Carl L. 382
Freed Transformer Co., Inc. 378

General Control Company 358
General Electric Company, X-Ray Department 225
General Precision Laboratory Incorporated 200
Genisco, Incorporated 357
Goodyear Aircraft Corporation 195
Governaire, Division of Bellofram Corporation 323
Graton & Knight Company 379

Hagan Corporation 251
Hammel-Dahl Company ..... Back Cover
Hathaway Instrument Company 240
Heise Bourdon Tube Company, Inc. 352
Helicoid Gage Division 326
Hexacon Electric Company 244
Hughes Research and Development Laboratories 333
Hycon Electronics, Inc. 327

Illinois Testing Laboratories, Inc. 230, 363
Industrial Engineering Corporation 236
International Business Machines Corp. 218

Jackson, Byron, Division, Borg-Warner Corporation 232
Johnson Company, E. F. 339

Kearfott Company, Inc. 201
Kellogg Switchboard & Supply Co. 307
Kenyon Transformer Co., Inc. 368
Kieley & Mueller, Inc. 263
Kollmorgen Optical Corporation 322

Leeds & Northrup Co. 256
Lehigh Chemical Company 320
Leslie Co. 238
Levin & Son, Inc., Louis 235
Lewis Engineering Company 210
Lewis Spring & Manufacturing Company 373
Librascope, Incorporated 202
Liquidepth Indicators, Incorporated 364
Logan Engineering Co. 230
Lynn, Robert M. 359, 383

Mallory & Co., Inc., P. R. 243
Manning, Maxwell & Moore, Inc. 229, 254
Marsh Instrument Co. 362
Marshalltown Manufacturing Co. 242
Martin Company, Glenn L. 377
Measurements Corporation 348
Mid-Century Instrumatic Corp. 306
Minneapolis-Honeywell Regulator Co., Industrial Division 234, 292-293
Moeller Instrument Company 228
Moser Jewel Company 358
Mueller Electric Co. 366

Nash Engineering Company 250
Nester Company, Inc., L. G. 372
New Hermes Engraving Machine Corp. 361
Ney Company, J. M. 378
Norden-Ketay Corporation 309
North American Aviation, Inc. 253

Optical Coating Laboratory, Inc. 363

Palmer Thermometers, Inc. 350
Panellit, Inc. 231
Perkin-Elmer Corporation 385
Permag Corporation 381
Photoswitch Division 349
Potter Instrument Company, Inc. 365
Powers Regulator Company 325, 364
Precision Products Company Inc of Waltham 367
Preis Engraving Machine Co., H. P. 381
Premier Metal Products Company 379
Pyrometer Instrument Co. 372

Radiation Inc. 241
Ramapo Instrument Company 384
Red Point Products, Inc. 366
Renick Co., L. C. 378
Republic Aviation 329
Rex Rheostat Co. 384
Richard Rimbach Associates 223
Rochester Manufacturing Co. 381
Rockwell Manufacturing Company 207

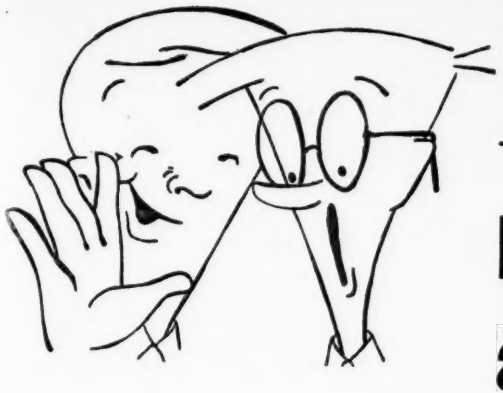
Sanborn Company 315
Scherr Optical Tools, Inc., Geo. 358
Sensitive Research Instrument Corporation 196
Shallcross Manufacturing Company 317
Shore Instrument & Mfg. Co., Inc. 374
Sigma Instruments, Inc. 319
Smith Company, S. Morgan 375
Sorensen & Company, Inc. 221
Southwestern Industrial Electronics Company 260
Statham Development Corporation 377
Statham Laboratories 313
Statolet Corp. 367
Sticht Co., Inc., Herman H. 382
Streeter-Amet Co. 360
Sturtevant Co., P. A. 376
Swiss American Jewel Bearings Co. 374

Teletronics Laboratory, Inc. 383
Testa Mfg. Co. 244
Texas Instruments Incorporated 198
Tower Supply Co. 384

Uehling Instrument Co. 374
Underwood Corporation 245
Unertl Optical Co., John 376
United States Gauge, Div. of American Machine & Metals, Inc. 321

Veeder-Root Incorporated 262
Victoreen Instrument Co. 370

Wallace & Tiernan Incorporated 233
Weber Electronics 372
Western Gear Corporation 206
Westronics, Inc. 360
Wheelco Instruments Div., Barber-Colman Company 226
Wilmad Glass Company, Inc. 362



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3	23	43	63	83	103	123	143	163	
4	24	44	64	84	104	124	144	164	
5	25	45	65	85	105	125	145	165	
6	26	46	66	86	106	126	146	166	
7	27	47	67	87	107	127	147	167	
8	28	48	68	88	108	128	148	168	
9	29	49	69	89	109	129	149	169	
10	30	50	70	90	110	130	150	170	
11	31	51	71	91	111	131	151	171	
12	32	52	72	92	112	132	152	172	
13	33	53	73	93	113	133	153		
14	34	54	74	94	114	134	154		
15	35	55	75	95	115	135	155		
16	36	56	76	96	116	136	156		
17	37	57	77	97	117	137	157		
18	38	58	78	98	118	138	158		
19	39	59	79	99	119	139	159		
20	40	60	80	100	120	140	160		

New Instruments									
201	221	241	261	281	301	321	341	361	
202	222	242	262	282	302	322	342	362	
203	223	243	263	283	303	323	343	363	
204	224	244	264	284	304	324	344	364	
205	225	245	265	285	305	325	345	365	
206	226	246	266	286	306	326	346	366	
207	227	247	267	287	307	327	347	367	
208	228	248	268	288	308	328	348	368	
209	229	249	269	289	309	329	349	369	
210	230	250	270	290	310	330	350		
211	231	251	271	291	311	331	351		
212	232	252	272	292	312	332	352		
213	233	253	273	293	313	333	353		
214	234	254	274	294	314	334	354		
215	235	255	275	295	315	335	355		
216	236	256	276	296	316	336	356		
217	237	257	277	297	317	337	357		
218	238	258	278	298	318	338	358		
219	239	259	279	299	319	339	359		
220	240	260	280	300	320	340	360		

New Literature									
401	421	441	461	481	501	521	541	561	
402	422	442	462	482	502	522	542	562	
403	423	443	463	483	503	523	543	563	
404	424	444	464	484	504	524	544	564	
405	425	445	465	485	505	525	545	565	
406	426	446	466	486	506	526	546	566	
407	427	447	467	487	507	527	547	567	
408	428	448	468	488	508	528	548	568	
409	429	449	469	489	509	529	549		
410	430	450	470	490	510	530	550		
411	431	451	471	491	511	531	551		
412	432	452	472	492	512	532	552		
413	433	453	473	493	513	533	553		
414	434	454	474	494	514	534	554		
415	435	455	475	495	515	535	555		
416	436	456	476	496	516	536	556		
417	437	457	477	497	517	537	557		
418	438	458	478	498	518	538	558		
419	439	459	479	499	519	539	559		
420	440	460	480	500	520	540	560		

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